NOTICE OF PROJECT CHANGE

Town of Orleans
Amended Comprehensive Wastewater Management Plan (ACWMP)

Submitted to:
Executive Office of Energy and Environmental Affairs
Massachusetts Environmental Policy Act Office

Prepared for:
Town of Orleans
19 School Rd
Orleans, MA 02653

December 2023

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Notice of Project Change Form

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ENCLOSURE: Town of Orleans 2023 Amended Comprehensive Wastewater Management Plan

Commonwealth of Massachusetts

Executive Office of Energy and Environmental Affairs ■ MEPA Office

Notice of Project Change

The information requested on this form must be completed to begin MEPA Review of a NPC in accordance with the provisions of the Massachusetts Environmental Policy Act and its implementing regulations (see 301 CMR 11.10(1)).

EEA # 14414		
Project Name: Town of Orleans – Comprehensive Wastewater Management Plan		
Street Address: Town-wide		
Municipality: Orleans	Watershed: Cape Cod	
Universal Transverse Mercator Coordinates:	Latitude: 41.7898 Longitude: -69.9897	
Estimated commencement date: April 2020	Estimated completion date: 2067	
Project Type: Wastewater Management	Status of project design: 10 %complete	
Proponent: Town of Orleans		
Street Address: 19 School Road		
Municipality: Orleans	State: MA	Zip Code: 02653
Name of Contact Person: Jennifer Doyle-Breen		
Firm/Agency: AECOM	Street Address: 250 Apollo Drive	
Municipality: Chelmsford	State: MA	Zip Code: 01824
Phone:978-905-2968	Fax: 978-905-2101	E-mail: Jennifer.doyle-breen@aecom.com

With this Notice of Project Change, are you requesting:

a Single EIR? (see 301 CMR 11.06(8)) ☐Yes ☒No
a Special Review Procedure? (see 301CMR 11.09) ☐Yes ☒No
a Waiver of mandatory EIR? (see 301 CMR 11.11) ☐Yes ☒No
a Phase I Waiver? (see 301 CMR 11.11) ☐Yes ☒No

Which MEPA review threshold(s) does the revised project meet or exceed (see 301 CMR 11.03)? Identify any new or modified review threshold(s) associated with the project change.

The revised project does not trigger any new MEPA thresholds; the original project triggered numerous thresholds, which remain for the revised project.

Which Agency Permits does the revised project require?

The permits required by the revised project are the same as those required by the most recently reviewed project and include the following:

MassDEP Wetlands Protection Act Local Order of Conditions
NHESP Project Review
MassDOT Permit/Approval
US EPA NDPES Construction General Permit for Stormwater Discharges
DMF Certification of Aquaculture

USACE Section 404 General Permit

MassDEP Effluent Discharge Permit
MassDEP Hydrological Approval

Identify any financial assistance or land transfer from an Agency of the Commonwealth for the revised project, including the Agency name and the amount of funding or land area in acres:

The Town has received SRF loans. Phase 1 loan for $59.7 million and Phase 2 loan for $29.4 million – the final loan amount has not been determined. The Town of Orleans has also received funding from the Cape Cod and Islands Water Protection Trust Fund to implement the initial phases of the ACWMP. The Town anticipates applying to the same funding sources for future sewer phases.

PROJECT INFORMATION

In 25 words or less, what is the project change? The project change involves . . .

Sewer service boundaries have been updated, the schedule for implementation has been extended, and full-scale PRBs are described.

See full project change description beginning on page 5 of this form.

Date of publication of availability of the ENF in the Environmental Monitor: (Date: 05/06/2009)

Was an EIR required? ☒Yes ☐No; if yes,
was a Draft EIR filed? ☐Yes (Date:) ☒No
was a Final EIR filed? ☐Yes (Date:) ☒No
was a Single EIR filed? ☒Yes (Date: Dec. 2010) ☐No

Have other NPCs been filed? ☒Yes (Date(s): 2/15/2019, 10/30/2018) ☐No

If this is an NPC solely for lapse of time (see 301 CMR 11.10(2)) proceed directly to **ATTACHMENTS & SIGNATURES**.

PERMITS / FINANCIAL ASSISTANCE / LAND TRANSFER
List or describe all new or modified Agency permits, financial assistance, or land transfers not previously reviewed: **include list of Agency Actions (e.g., Agency Project, Financial Assistance, Land Transfer, List of Permits)**

There are no new or modified Agency permits, financial assistance, or land transfers.

Are you requesting a determination that this project change is insignificant such that an EIR should not be required (***note that the Proponent may also seek an advisory ruling under 301 CMR 11.10(6)***)? A change in a Project is ordinarily insignificant if it results solely in

an increase in square footage, linear footage, height, depth, or other relevant measures of the physical dimensions of the Project of less than 10% overestimates previously reviewed, provided the increase does not meet or exceed any review thresholds. A change in a Project is also ordinarily insignificant if it results solely in an increase in impacts of less than 25% of the level specified in any review threshold, provided that cumulative impacts of the Project do not meet or exceed any review thresholds that were not previously met or exceeded. (See 301 CMR 11.10(6))

☒**Yes** ☐**No; if yes, provide an explanation of this request in the Project Change Description below.**

FOR PROJECTS SUBJECT TO AN EIR

If the project requires the submission of an EIR, are you requesting that a Scope in a previously issued Certificate be rescinded?
☐**Yes** ☒**No; if yes, provide an explanation of this request_____.**

If the project requires the submission of an EIR, are you requesting a change to a Scope in a previously issued Certificate?
☐**Yes** ☒**No; if yes, provide an explanation of this request_____.**

SUMMARY OF PROJECT CHANGE PARAMETERS AND IMPACTS*

Summary of Project Size & Environmental Impacts	Previously reviewed	Net Change	Currently Proposed
LAND			
Total site acreage	27.4	0	27.4
Acres of land altered	1.6	0	1.6
Acres of impervious area	51.5	0	51.5
Square feet of bordering vegetated wetlands alteration	0	0	0
Square feet of other wetland alteration	6	+3,000	3,006**
Acres of non-water dependent use of tidelands or waterways	0	0	0
STRUCTURES			
Gross square footage	59,200	0	59,200
Number of housing units	0	0	0
Maximum height (in feet)	25	0	25
TRANSPORTATION			
Vehicle trips per day	26	0	26
Parking spaces	12	0	12

WATER/WASTEWATER			
Gallons/day (GPD) of water use	N/A	N/A	N/A***
GPD water withdrawal	0	0	0
GPD wastewater generation/ treatment	640,000	+60,000	700,000
Length of water/sewer mains (in miles)	74.9	-26.43	48.5

***** Numbers do not include temporary alterations in off-road segments. Temporary work in Land Under Water (LUW), Bank, Riverfront Area, and Bordering Land Subject to Flooding (BLSF) resource areas for sewer line installation will be restored to existing grades in all locations.
** Permanent impacts are due to three tentative pump station locations in Bordering Land Subject to Flooding, Land Subject to Coastal Storm Flowage, and/or salt marsh. Each pump station is estimated to be approximately 1,000 Square feet in area. Pump stations have been conceptually sited at required low topographic points near required wastewater infrastructure for planning purposes, however final siting and associated analysis will occur during design for each future phase, and locations will be adjusted, if possible, to avoid permanent wetland resource area impacts. Although previously reviewed "other" wetland alteration was 0, this was due to lack of confirmation of specific pump station sites.
*** This project will not affect water use

Does the project change involve any <u>new or modified</u>:

1. conversion of public parkland or other Article 97 public natural resources to any purpose not in accordance with Article 97? ☐**Yes** ☒**No**
2. release of any conservation restriction, preservation restriction, agricultural preservation restriction, or watershed preservation restriction? ☐**Yes** ☒**No**
3. impacts on Rare Species**?** ☐**Yes** ☒**No**
4. demolition of all or part of any structure, site or district listed in the State Register of Historic Place or the inventory of Historic and Archaeological Assets of the Commonwealth? ☐**Yes** ☒**No**
5. impact upon an Area of Critical Environmental Concern? ☐**Yes** ☒**No**

If you answered 'Yes' to any of these 5 questions, explain below:

<u>PROJECT CHANGE DESCRIPTION</u> (attach additional pages as necessary). The project change description should include:

(a) a brief description of the project as most recently reviewed,

(b) a description of material changes to the project as previously reviewed,

(c) if applicable, the significance of the proposed changes, with specific reference to the factors listed 301 CMR 11.10(6), and

(d) measures that the project is taking to avoid Damage to the Environment or to minimize and mitigate unavoidable environmental impacts. If the change will involve modification of any prior mitigation commitments or previously issued Section 61 Finding, include a description of any such changes and a draft of the modified Section 61 Finding (or it will be required in Supplemental EIR).

The project change description should include a comprehensive description of the proposed project change, including a description of any work or activities associated with the original project that have occurred to date. At the discretion of the MEPA Office, an alternatives analysis for the changed component(s) of the project may be required, including a summary of alternatives considered and associated environmental impacts at a level of detail commensurate with the scope and scale of the proposed change. In addition to the required attachments, the filing should include supporting technical data (e.g., a Traffic Impact and Access Study, Stormwater Report, etc.) as

appropriate. It should include a full list of mitigation commitments that remain unchanged from the previously reviewed project.

(a) Brief description of the project as most recently reviewed

The project described in the 2010 CWMP/SEIR included a 20-year phased construction of a wastewater collection system, a new WWTF, and implementation of non-structural program elements to achieve reductions in nitrogen loadings to coastal embayments. Since the Comprehensive Wastewater Management Plan (CWMP) was first approved in 2011, additional studies, wastewater engineering, and planning decisions have been made. In October 2018, a Notice of Project Change (NPC) was submitted to MEPA to modify the effluent discharge location and technology. A MEPA Certificate was issued approving the new discharge location at 32/43 Lots Hollow Road via wick wells. In March 2019, a second NPC indicated that the Town had implemented Demonstration Projects for aquaculture and permeable reactive barriers (PRBs) to assess the potential of these Non-Traditional Technologies (NTs) to remove nitrogen. The demonstration projects implemented are Lonnie's Pond aquaculture operation and PRBs at Eldredge Park. The 2019 NPC also described the Town's intent to contract with a third party to continue aquaculture operations at Lonnie's Pond and that the 2018 MassDEP Watershed Permit and associated Targeted Watershed Management Plan (TWMP) identified the Lonnie's Pond aquaculture project as one of the Town of Orleans' components for removing nitrogen.

(b) Description of material changes to the project as previously reviewed

The material changes to the previously reviewed project include the following:

- Revisions to the sewer phase boundaries while substantially maintaining the originally sewered area limits
- Extension of the time period to construct wastewater collection facilities in these sewer phases
- Identification of Permeable Reactive Barrier sites for further evaluation and full-scale implementation
- Elimination of consideration of aquaculture at sites other than Lonnie's Pond
- Elimination of consideration of other NT Technologies for nitrogen removal
- Preparation of an Amended CWMP (ACWMP) to reflect the changes noted above as well as provide an update on planning and engineering efforts completed since approval of the original CWMP in 2011

A summary of these changes are provided below, and additional details are provided in the enclosed ACWMP document.

Updated Sewer Phasing and Phase Scheduling

The Town of Orleans has revised the sewer phasing and the anticipated construction time frame for each phase (**Attachment 3**). The 2023 phases correspond to the 2010 CWMP "Core Area" but extend the time period for completing sewer installation in these areas. The current thinking is to extend to 2067 due to multiple considerations, including the Town's need to address other financial needs and continuing studies on PRBs and nitrogen attenuation.

Permeable Reactive Barriers Full-Scale Implementation

The Town of Orleans has described full scale PRB implementation in the ACWMP. The 2021 "Full-Scale PRB Watershed Planning Memorandum" examined the viability of PRBs in Nauset Estuary, Rock Harbor, and Pleasant Bay locations. AECOM performed a preliminary assessment for nitrogen removal effectiveness at these sites by evaluating the dimensions of the proposed PRBs, groundwater flow direction, upgradient wastewater nitrogen source density, and expected adherence to PRB nitrogen remediation goals. In the Nauset Estuary, additional geotechnical and hydrogeological evaluation are needed for the Norseman PRB to confirm the efficacy of a PRB in this location. No Rock Harbor sites were recommended for further examination. In the Pleasant Bay location, the Duck Hole site was recommended for further consideration. The Mayflower and Lockwood sites were selected for further consideration based on their location relative to groundwater flows and their position in the watershed, which maximizes potential for intercepting and treating nitrogen in the groundwater. The next steps for potential PRB implementation include additional baseline field investigations at the Norseman site in the Nauset Watershed and Mayflower and Lockwood sites in the Pleasant Bay Watershed, as well as final design of the Duck Hole PRB.

Other Non-Traditional Technologies

Non-Traditional (NT) Technologies were considered as part of the Hybrid Approach to wastewater management in Orleans. Aquaculture was one recommended NT Technology. Only the Lonnie's Pond demonstration project was fully implemented. Other aquaculture sites were determined to be not cost-effective. The Town does not plan to expand the program to locations other than Lonnie's Pond at this time. Floating constructed wetlands (FCWs) were considered but the Town decided to curtail pursuit of FCW implementation after review of the costs for implementing FCWs, operations and maintenance considerations, as well as the uncertainty of the nitrogen removal that could be achieved. Nitrogen reducing biofilters (NRBs) were also evaluated by the Town of Orleans to determine the efficacy in managing nitrogen at its source. NRBs were dropped from consideration after no suitable demonstration sites could be identified and upon further consideration of relative cost effectiveness.

Amended Comprehensive Wastewater Management Plan (ACWMP)

The Amended CWMP (ACWMP) builds upon earlier studies and data collection completed for the 2010 CWMP and Single Environmental Impact Report (SEIR) and provides an update on the additional planning and engineering efforts that were completed since approval in 2011 and two subsequent NPCs. The ACWMP has been developed to provide an update on the Town's plans to meet their nitrogen removal goals and to give an overview of the Town's approach to tracking nitrogen removal by watershed based on water use data. The ACWMP is provided with this NPC form for review.

(c) If applicable, the significance of the proposed changes, with specific reference to the factors listed 301 CMR 11.10(6)

(a) Expansion of the Project

The ACWMP does not represent an expansion of the project. The 2010 CWMP identified a "Core" sewer service area and an "Extended" area, which included the potential to extend sewers throughout all of the Town of Orleans. The currently proposed extent of sewering conforms to the original "Core" area. The use of Non-Traditional Technologies was previously

identified, both in the original CWMP and the 2019 NPC. The 2019 NPC identified that the Town was considering additional locations for PRBs. The wastewater collection infrastructure identified in the ACWMP decreases the length of sewer pipe and the number of pump stations due to a greater emphasis on gravity sewers compared to low-pressure sewers. The 2010 CWMP identified the need for over 50 pump stations, whereas the currently proposed plan includes only 14 pump stations. Similarly, the length of sewer pipe required has decreased from approximately 75 miles to approximately 49 miles. The greater length of sewer and higher number of pump stations in the 2010 CWMP was due to a greater reliance on low-pressure sewers compared to the currently proposed sewering approach which includes more gravity sewers, and therefore fewer pump stations and associated force mains.

(b) Generation of further impacts

The ACWMP does not generate impacts in excess of those originally anticipated in the 2010 CWMP. The 2010 CWMP identified a "Core" sewer service area and an "Extended" area, which included the potential to extend sewers throughout all of the Town of Orleans. The Lonnie's Pond aquaculture work was previously described and evaluated in the 2019 NPC. The new component described in the 2023 ACWMP is permeable reactive barriers (PRBs). The addition of PRB sites will not generate further impacts to protected areas or exceed any MEPA review thresholds. The Mayflower and the Lockwood PRB sites are located within the Pleasant Bay ACEC and the Duck Hole PRB site is located partially within the Pleasant Bay ACEC and partially within an area mapped as a Natural Heritage and Endangered Species Program (NHESP) Estimated and Priority Habitat. However, work in these resource areas was anticipated at the time of the 2010 CWMP, and the PRBs would be located in roads, and therefore are not anticipated to result in a "Take" of protected species, although this will be further evaluated through consultation with NHESP once design of the PRBs progresses.

(c) Change in expected date for commencement of the project, commencement of construction, completion date for the project, or schedule of work on the project.

Construction of Phase 1 of the previously approved Core Program was anticipated to be completed in 2017; Phase 2 was anticipated to be completed in 2020; and Phase 3 was anticipated to be completed in 2023, and future phases extended to 2032. Phase 1 of the Core Program was completed in 2023, Phase 2 is currently under construction, and Phase 3 is currently in the study phase, with future phases extended through 2067. As described in the ACWMP, there is currently uncertainty regarding nitrogen removal goals for Nauset Harbor and the extended schedule allows for time for Nauset modeling to be updated and the nitrogen removal goals to be refined. Although the completion date for all phases is later than originally anticipated, water quality benefits associated with the project will still be achieved. The extended schedule was discussed with MassDEP at a pre-application meeting in September 2023 and no concerns were expressed.

(d) Change of the project site

No change in project site is proposed. The 2010 CWMP identified a "Core" sewer service area and an "Extended" area, which included the potential to extend sewers throughout all of the Town of Orleans. The Duck Hole PRB site is located along a road in the 2010 "Phase 6" area, while the other three PRB sites (Norseman, Mayflower, and Lockwood") are located in the "Extended" area.

(e) New application for a permit or new request for financial assistance or a land transfer

There are no new applications or financial assistance requests not previously identified and reviewed in the CWMP/SEIR.

(f) For a project with net benefits to environmental quality and resources or public health, any change that prevents or materially delays realization of such benefits

This project has net benefits to the environment. Although the extension of sewer phases into the future will delay some nitrogen removal, Phases 1 (construction completed), 2 (construction underway) and 3 (sewer study underway) are anticipated to remove approximately 42% of the Pleasant Bay nitrogen reduction goal identified in the current TMDL, assuming a removal rate of 4 kg of nitrogen per parcel. The ongoing aquaculture at Lonnie's Pond is removing additional nitrogen from Pleasant Bay, and the Town's overall approach is in compliance with the Pleasant Bay Watershed Permit. The first three sewer phases of the ACWMP are similarly anticipated to remove approximately 35% of the nitrogen removal goals identified in the 2012 Nauset Harbor Massachusetts Estuaries Program (MEP) Report, and 100% of the nitrogen removal goals identified in the 2008 Rock Harbor MEP report. In addition, MassDEP has acknowledged that an update to the Nauset Harbor MEP modeling is required. As described in the ACWMP, there is currently uncertainty regarding nitrogen removal goals for Nauset Harbor and the extended schedule allows time for Nauset modeling to be updated and the nitrogen removal goals to be refined. The extended schedule was discussed with MassDEP at a pre-application meeting in September 2023 and no concerns were expressed. Refer to ACWMP for further detail.

(g) Lapse of time

This criterion is not applicable as the Town has been continuously advancing elements of the original 2010 CWMP since its approval in 2011.

(d) Measures that the project is taking to avoid Damage to the Environment or to minimize and mitigate unavoidable environmental impacts.

The previously reviewed CWMP/SEIR identified measures to avoid damage to the environment or minimize and mitigate unavoidable environmental impacts, as summarized below. The change will not involve modification of any previously issued mitigation measures or Section 61 Finding. Mitigation measures that will be employed during the construction period and/or once the facility is operational include:

- Sewer construction on primary roads is seasonally restricted
- Segmenting sewer work on public streets to avoid protracted closures
- Designing sewer lines and pump station to avoid floodplains and to minimize encroachment on the buffers of wetlands and other protected resource areas where practical
- Restricting work hours on construction sites near residential areas
- Requiring contractors to implement dust control measures
- Erosion and siltation controls at all construction sites
- Compliance with all terms of Orders of Conditions for work in wetland buffers
- Installation of odor and noise control systems on operating equipment and facilities

- Implementation of policies that restrict potential odor-generating activities to times of the day with the least impact
- Compliance with applicable standards for construction activities near historic structures
- Avoid, minimize, and mitigate impacts to habitat of rare and endangered species, including compliance with all NHESP conditions
- Selection of wastewater treatment equipment to minimize energy use and maximize nitrogen removal
- Adoption of bylaws and regulations to ensure a "growth neutral" program

Additional mitigation measures to address abutters' concerns at Lonnie's Pond ' have been implemented, include minimizing noise and restricting working hours. Visual impacts have been addressed by using black floating mesh bags, removing aquaculture gear annually, and minimizing the number of vehicles parked on the boat ramp and limiting them to one side. To minimize the impacts to the substrate in Lonnie's Pond, the use of a narrow diameter telescoping anchor has been used. These occupy much less area than blocks.

ATTACHMENTS & SIGNATURES

Attachments:
1. Secretary's most recent Certificate on this project
2. Plan showing most recent previously reviewed proposed build condition
3. Plan showing currently proposed build condition
4. Original U.S.G.S. map or good quality color copy (8-1/2 x 11 inches or larger) indicating the project location and boundaries
5. List of all agencies and persons to whom the proponent circulated the NPC, in accordance with 301 CMR 11.10(7)

Signatures:

12/12/23	Signature of Responsible Officer or Proponent	12/12/23	Signature of person preparing NPC (if different from above)

Kimberly Newman	Jennifer Doyle-Breen
Name (print or type)	Name (print or type)
Town of Orleans	AECOM
Firm/Agency	Firm/Agency
19 School Road	250 Apollo Drive
Street	Street
Orleans, MA 02653	Chelmsford, MA 01824
Municipality/State/Zip	Municipality/State/Zip
(508) 240-3700 ext. 2415	(978) 905-2968
Phone	Phone

ATTACHMENT 1

2019 CERTIFICATE OF THE SECRETARY OF ENERGY AND ENVIRONMENTAL AFFAIRS ON THE NOTICE OF PROJECT CHANGE FOR NITROGEN REMOVAL

The Commonwealth of Massachusetts
Executive Office of Energy and Environmental Affairs
100 Cambridge Street, Suite 900
Boston, MA 02114

Charles D. Baker
GOVERNOR

Karyn E. Polito
LIEUTENANT GOVERNOR

Matthew A. Beaton
SECRETARY

Tel: (617) 626-1000
Fax: (617) 626-1081
http://www.mass.gov/eea

April 19, 2019

CERTIFICATE OF THE SECRETARY OF ENERGY AND ENVIRONMENTAL AFFAIRS
ON THE
SECOND NOTICE OF PROJECT CHANGE

PROJECT NAME	: Town of Orleans – Comprehensive Wastewater Management Plan – Non-Traditional Technologies for Nitrogen Removal
PROJECT MUNICIPALITY	: Orleans
PROJECT WATERSHED	: Cape Cod
EEA NUMBER	: 14414
PROJECT PROPONENT	: Town of Orleans
DATE NOTICED IN MONITOR	: March 20, 2019

Pursuant to the Massachusetts Environmental Policy Act (MEPA; M.G. L. c. 30, ss. 61-62I) and Section 11.10 of the MEPA regulations (310 CMR 11.00), I hereby determine that this project **does not require** an Environmental Impact Report (EIR).

Original Project and Procedural History

The Orleans Comprehensive Wastewater Management Plan (CWMP) calls for the 20-year phased construction of a wastewater collection system and new, centralized Wastewater Treatment Facility (WWTF) as well as implementation of non-structural program elements to achieve reductions in nitrogen loading to coastal embayments over a 20-year period. Specifically, the CWMP includes: construction of a 0.64 million gallons per day (mgd) WWTF at the Tri-Town Septage Treatment Facility on Overland Way; installation of 74 miles of sewer pipes and 63 pump stations in six construction phases to treat wastewater from 2,800 properties along Pleasant Bay, Town Cove, and the Nauset and

Rock Harbor watersheds (referred to as the Core Program); an adaptive management plan (AMP) that includes compliance with Total Maximum Daily Load (TMDL) requirements, monitoring for nitrogen loading reductions, and making changes to the CWMP as necessary in response to new data; and evaluation of opportunities to accommodate additional wastewater flows from Eastham and/or Brewster (referred to as the Regional Program).

A Certificate on the Single EIR for the CWMP was issued on January 28, 2011 and indicated that it adequately and properly complied with MEPA and its implementing regulations. In January 2018, the Town submitted the first NPC. The NPC proposed to shift the location of the effluent disposal site from the Tri-Town Septage Treatment Facility to 32 Lots Hollow Road and identified 43 Lots Hollow Road as a reserve site. On December 7, 2018, I issued a Certificate on the first NPC in which I determined that the potential impacts associated with the project change did not require an EIR.

Second Notice of Project Change

The second NPC was submitted to incorporate the following two demonstration projects into the CWMP: a permeable reactive barrier (PRB) at Eldredge Park and oyster aquaculture in Lonnie's Pond. These demonstration projects utilize non-traditional technologies to remove nitrogen and were not previously included within the Town's CWMP. Both demonstration projects were deployed in 2016. The Town has monitored these projects and has two to three years of monitoring data with which to evaluate their effectiveness in removing nitrogen. The second NPC also provided an update on wastewater planning activities that have occurred since the 2011 CWMP.

Demonstration Project Sites

The PRB is located within Eldredge Park at 78 Eldredge Park Way in Orleans. Specifically, the PRB is located in the parking lot area between the Nauset Middle School playing fields and the Town-owned Eldredge Park baseball field. The 100-foot (ft) long PRB is oriented northwest to southeast, perpendicular to the northeasterly groundwater flow direction. Physical structures associated with the PRB include 42 two-inch diameter monitoring wells which are flush mounted and occupy less than 1 square foot (sf). Groundwater generally flows toward Town Cove which is located approximately 2,400 ft to the northeast. Lonnie's Pond (Pond) (also known as Kescayo-Gansett Pond) is located within the upper reaches of the Pleasant Bay watershed. The Pond contains mapped shellfish habitat for quahogs *(Mercenaria mercenaria)* and soft shell clams *(Mya arenaria).* According to the Division of Marine Fisheries (DMF), the Pond provides anadromous/catadromous fish passage and migration habitat for alewife *(Alosa pseudoharengus)* and american eel *(Anguilla rostrate).* Salt marsh is located around the shoreline of the Pond. The Pond is located within the designated Pleasant Bay Area of Critical Environmental Concern (ACEC). Neither demonstration project is located within Priority and/or Estimated Habitat as mapped by the Division of Fisheries and Wildlife's (DFW) Natural Heritage and Endangered Species Program (NHESP).

Jurisdiction and Permitting

The CWMP is undergoing MEPA review and is subject to preparation of a Mandatory EIR pursuant to 301 CMR 11.03(5)(a)(3) of the MEPA regulations because it requires State Agency Actions and will result in the construction of one or more new sewer mains of ten or more miles in length.

Implementation of the CWMP will require a Groundwater Discharge Permit (GWDP) from the Massachusetts Department of Environmental Protection (MassDEP) and may require a Conservation and Management Permit (CMP) from the NHESP and a Non-Vehicular Access Permit(s) from the Massachusetts Department of Transportation (MassDOT).

Implementation of the CWMP will require an Order of Conditions from the Orleans Conservation Commission (or in the case of an appeal, a Superseding Order of Conditions from MassDEP) and a National Pollutant Discharge Elimination System (NPDES) Construction General Permit from the U.S. Environmental Protection Agency (EPA). It may require a Section 404 Permit from the U.S. Army Corps of Engineers (ACOE) and Federal Consistency Review by the Office of Coastal Zone Management (CZM).

The second NPC indicated that the aquaculture demonstration project in Lonnie's Pond will require DMF's certification of the private shellfish aquaculture license pursuant to MGL c. 130 § 57. The PRB demonstration project does not require any Agency Actions.

The Town has applied for State Financial Assistance in the form of a $45 million loan from the Clean Water State Revolving Fund (SRF) to plan, design, and implement the CWMP. Therefore, MEPA jurisdiction is broad and extends to all aspects of the project that are likely, directly or indirectly, to cause Damage to the Environment, as defined in the MEPA regulations.

Environmental Impacts and Mitigation

As described in the second NPC, the project changes will increase the total site acreage (from 27 acres to 27.37 acres) and will increase impacts to Land Under Water (LUW) (from 0 sf to 6 sf). The NPC will not change impacts to land alteration (4 acres), impervious area (4 acres), or rare species habitat (4.9 acres) from those previously reviewed.

Measures to avoid, minimize, and mitigate impacts include: comprehensive water quality monitoring plan for Lonnie's Pond, use of black floating bags to minimize visual impacts, requirements for annual removal of aquaculture gear, commitments to address abutters concerns (visual impacts, noise, restricting work hours, limiting parking), and rotating oyster bags across several locations.

Review of the NPC

The second NPC included a description of the project as previously proposed, described the two demonstration projects, and included conceptual site plans. It identified potential environmental impacts and described measures to avoid, minimize, and mitigate impacts associated with the two projects.

Comments from MassDEP, CZM, and DMF emphasize the importance of the Town continuing its CWMP planning process; including continued evaluation of more traditional means of nutrient reduction and source reduction strategies. Comments from MassDEP identify additional information that should be addressed in subsequent submittals and emphasize the importance of providing a comprehensive update of the CWMP.

Wastewater Planning

The NPC provided an update on wastewater planning activities that have occurred since the CWMP was reviewed by MEPA in 2011. In 2014, the Town convened the Orleans' Water Quality Advisory Panel (OWQAP) to investigate the use of non-traditional technologies to achieve nitrogen removal goals. In 2015, the OWQAP developed a written Consensus Agreement and associated Consensus Plan figure which proposed a hybrid approach to nitrogen removal consisting of traditional and non-traditional technologies that would provide the Town with a more cost-effective strategy for reducing nitrogen in Rock Harbor, Nauset Marsh, Pleasant Bay, Namskaket, and Little Namskaket Watersheds. The Town did not formally amend the CWMP to incorporate the hybrid approach. The Consensus Agreement identified the following non-traditional technologies: Permeable Reactive Barriers (PRB), floating constructed wetlands, shellfish aquaculture, and coastal habitat restoration reefs. As described below, two technologies have progressed to the demonstration project phase (PRBs and aquaculture). The second NPC indicated that floating constructed wetlands were dismissed due to insufficient data to evaluate the effectiveness of this technology. The second NPC indicated the Town is currently evaluating locations to implement a Nitrogen Reducing Biofilter (NRB) demonstration project.

In 2018, the Pleasant Bay Alliance (PBA), comprised of Orleans, Chatham, Brewster, and Harwich, developed the *Pleasant Bay Targeted Watershed Management Plan* (TWMP). The TWMP documented the mitigation measures that each municipality must implement to reduce its share of nitrogen contribution to Pleasant Bay in accordance with TMDL requirements. Oyster aquaculture in Lonnie's Pond was identified in the TWMP as one of the measures the Town must implement. In August 2018, MassDEP issued a Watershed Permit that authorized work to implement the recommendations in the TWMP and achieve identified water quality improvements. The Watershed Permit established performance standards and timeframes under an adaptive management framework for the actions outlined in the TWMP, including aquaculture at Lonnie's Pond. The Watershed Permit requires the submittal of monitoring data to MassDEP to inform development of a nitrogen removal credit for aquaculture at Lonnie's Pond. The Town has not determined whether it will implement a full-scale aquaculture program. The Watershed Permit also requires the Town to amend the CWMP by 2023. As described below in greater detail, the Town should submit a NPC to the MEPA Office consisting of a comprehensive amendment to the CWMP.

Demonstration Projects

The second NPC indicated the Town is considering implementing the following non-traditional technologies to reduce or attenuate nitrogen loading: additional PRB demonstration project(s), additional aquaculture demonstration project(s), coastal habitat restoration reef demonstration project(s), and NRB demonstration project(s). As noted previously, the second NPC provided a description of the PRB at Eldredge Park and the Lonnie's Pond aquaculture demonstration projects; identified potential environmental impacts and included monitoring data for both projects (Attachments 4 and 5 of the second NPC).

The second NPC did not address environmental impacts associated with other non-traditional technologies or additional demonstration projects.

The PRB was installed in November 2016 and has been monitored quarterly since January 2017. Data collected includes the lateral and vertical movement of the emulsified vegetable oil through the ground, the extent of nitrogen reduction in the groundwater, and the migration path of the groundwater plume. The Town will complete monitoring in the fall of 2019. Data provided with the second NPC indicated reductions in nitrate concentrations over baseline conditions at some downstream monitoring wells. According to the second NPC, the ability of the PRB to decrease nitrate concentrations is reduced due to locally variable groundwater flow conditions and a previously unidentified upstream source of high nitrate concentration. The Town is evaluating corrective actions, including expanding and realigning the PRB and increasing the number of monitoring wells. The Town is evaluating additional locations for PRBs; a location has not been selected.

The Town conducted the aquaculture demonstration project in Lonnie's Pond for three years (2016 - 2018) to evaluate nitrogen uptake under various oyster stocking density scenarios and to determine logistics of implementing oyster aquaculture. According to the second NPC, Lonnie's Pond was selected as the preferred location for the demonstration project because of its favorable growing conditions and site specific characteristics which facilitates monitoring water quality and sediment denitrification. The Town collected data on temperature, salinity, total nitrogen, and other parameters in accordance with the requirements of the Watershed Permit. Oyster culture was deployed in floating bags, attached to long-lines, and anchored by a series of telescoping augurs. In 2016, 200,000 oysters (averaging 10.5% nitrogen content each) were deployed over a 0.22-acre area and removed 25.9 kilograms (kg) of nitrogen by uptake. In 2017, 600,000 oysters (averaging 10.3% nitrogen content each) were deployed over a 0.19-acre area and removed 28.1 kg of nitrogen. In 2018, oysters were deployed over a 0.37-acre area. Data from 2018 is still being analyzed. Results from the first two years indicate that a 1-acre, full-scale aquaculture project could achieve the annual reductions in nitrogen identified in the Massachusetts Estuaries Project (MEP) for Lonnie's Pond (300 kg/year) and could support attainment of TMDLs for this sub-embayment.

The aquaculture activities in Lonnie's Pond were conducted by the Town under the authority of their municipal propagation permit. According to the second NPC, the Town has elected to contract with a third party to continue the aquaculture demonstration project at Lonnie's Pond during 2019 and beyond. This will require certification of a private aquaculture license by DMF under MGL 130 §57. Comments from MassDEP – Waterways confirm that this demonstration project will not require a Chapter 91 (c.91) License as it is a seasonal installation that is not intended to remain in place permanently.

Approximately 5.5 million 2-3 millimeter (mm) seed oysters will be deployed by June 1. The project will consist of 2,040 black, floating bags over a 0.37-acre area of Lonnie's Pond. Gear will be installed annually in the spring and removed no later than December 15th in any given year. The bags will be located in two areas of the Pond (the south side and northeast side). Each location will be divided into six sections and only two of the six sections in each location will be occupied in any given year. The Town anticipates that the project will remove 75 kg of nitrogen. The Town will hire an Aquaculture Contractor who will be responsible for purchasing, transporting, installing, maintaining, and removing the shellfish. The Town will also hire a Monitoring Contractor to conduct water quality monitoring in Lonnie's Pond and to calculate the amount of nitrogen uptake by the oysters on an annual basis. The second NPC identified requirements for the contractor regarding: contingency plans for catastrophic

events, monitoring and reporting, shellfish sampling, time-of-year restrictions for gear removal, and development of a Quality Assurance Project Plan (QAPP) for review by the Town and MassDEP.

The Town will continue to evaluate these two demonstration projects; no decisions have been made in regard to full-scale implementation of these technologies. Consultation with MassDEP is necessary to establish the amount of nitrogen removal credit that could be assigned to each technology. Upon establishment of a nitrogen removal credit, the Town may propose to reduce the sewer area outlined in the 2011 CWMP with a combination of these non-traditional technologies. The Town may continue implementation and monitoring of the Lonnie's Pond aquaculture demonstration project and the PRB; however, full-scale implementation of non-traditional nitrogen removal technologies must be reviewed through the Amended CWMP.

Amended CWMP/NPC

The Town must amend its CWMP by 2023 as required by the MassDEP Watershed Permit. The Amended CWMP will be subject to MEPA review in the form of a NPC. The Amended CWMP/NPC should provide an update on each of the core elements of the CWMP (as applicable), describe each element, identify any changes since the Single EIR was reviewed, and include an updated summary of environmental impacts associated with implementation of the CWMP.[1]

The Amended CWMP/NPC should include an updated summary of mitigation measures, draft Section 61 Findings, and an updated schedule for implementation of the remaining phases of the CWMP. It should also address Executive Order 569: *Establishing an Integrated Climate Change Strategy for the Commonwealth* (EO 569), which was issued in September 2016. I refer the Town to the Certificate on the first NPC for additional guidance on EO 569. The Town should consult with MassDEP and the MEPA Office prior to preparing the NPC.

The Amended CWMP/NPC should address the extent to which full-scale implementation of non-traditional nitrogen removal technologies will reduce the sewer collection area or other infrastructure components identified in the 2011 CWMP. The Amended CWMP/NPC should identify the proposed sites, include maps and plans at a reasonable scale that clearly locate and delineate project elements and environmental resources within the project area. The Amended CWMP/NPC must include a list of required permits and a timetable and cost estimate for each non-traditional technology. It should identify the estimated percent of nitrogen removal that could be achieved by each proposed technology compared to the necessary nitrogen removal identified as necessary by the MEPs for these watersheds**.** I refer the Town to the MassDEP comment letter for additional guidance on information that should be provided in the Amended CWMP/NPC. It should also include an alternatives analysis that describes siting criteria, and identifies potential environmental impacts associated with each alternative. The Amended CWMP/NPC should identify measures to avoid, minimize and mitigate environmental impacts. To the extent that agency comments on the Single EIR, first and/or second NPC identified issues, concerns and/or provided recommendations associated with a non-traditional technology, they should be addressed in the NPC.

[1] Core elements of the CWMP include: Orleans WWTF, Core Program, Non-Structural Program Elements, Adaptive Management Plan, and Regional Wastewater Management Opportunities.

The narrative within the second NPC referred to additional evaluations, data, and monitoring results provided within a series of annual reports, which were provided electronically. The information itself was not described or summarized within the narrative of the second NPC. All future submittals should provide a full and self-contained description and analysis of the project for the MEPA record, including a summary of monitoring data. It should provide additional narrative to explain and support the analysis of the project's impacts and mitigation, and extract relevant documentation and tables from technical appendices to supplement the narrative.

Conclusion

The NPC has sufficiently defined the nature and general elements of the two demonstration projects for the purposes of MEPA review and demonstrated that environmental impacts can be avoided, minimized, and/or mitigated to the extent practicable. Based on the information in the NPC and after consultation with State Agencies, I find that no further MEPA review is required at this time. I encourage the Town to consult with the MEPA Office prior to filing the Amended CWMP/NPC.

April 19, 2019
Date

Matthew A. Beaton

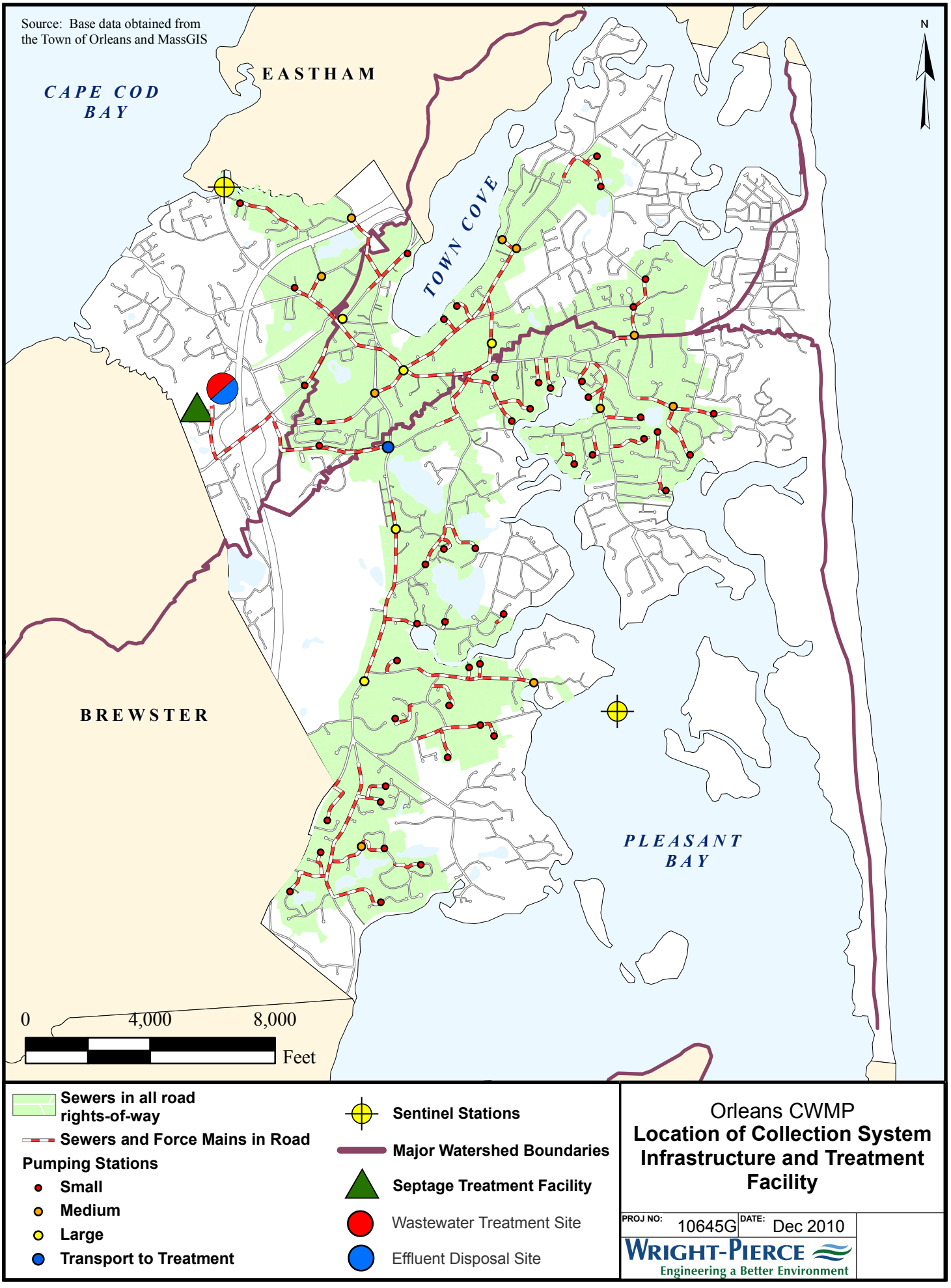
Comments received:

04/04/2019 Massachusetts Historical Commission (MHC)
04/08/2019 Natural Heritage and Endangered Species Program (NHESP)
04/09/2019 Office of Coastal Zone Management (CZM)
04/09/2019 Division of Marine Fisheries (DMF)
04/09/2019 Massachusetts Department of Environmental Protection (MassDEP) – Southeast Regional Office
04/12/2019 MassDEP – Waterways Program

MAB/PRC/prc

ATTACHMENT 2

PREVIOUS PROPOSED BUILD CONDITION



Orleans CWMP
Location of Collection System Infrastructure and Treatment Facility

PROJ NO: 10645G DATE: Dec 2010

WRIGHT-PIERCE
Engineering a Better Environment

W:\GIS_Development\Projects\10645B-Orleans\10645G\2010_CWMP_SEIR\Fig11-1.mxd

TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING

Notice of Project Change

2018 DOWNTOWN SERVICE AREA
COLLECTION SYSTEM LAYOUT

Legend

- Proposed Gravity Sewer
- Existing Gravity Sewer
- Properties proposed to be served by LPS
- PS Forcemain
- WWTF Effluent Forcemain
- Proposed LPS
- Downtown Service Area
- Areas of Critical Environmental Concern

0 300 600
Feet

AECOM

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Proposed Route 6 Crossing

Vicinity of Proposed Namskaket Pump Station

Proposed Wastewater Treatment Facility Project Area

32 Lots Hollow Rd (Water Tower Site) Proposed Effluent Disposal Area

43 Lots Hollow Rd

Vicinity of Proposed Nauset Pump Station

Vicinity of Proposed Snow Pump Station

Namskaket Marsh

Cedar Pond

Boland Pond

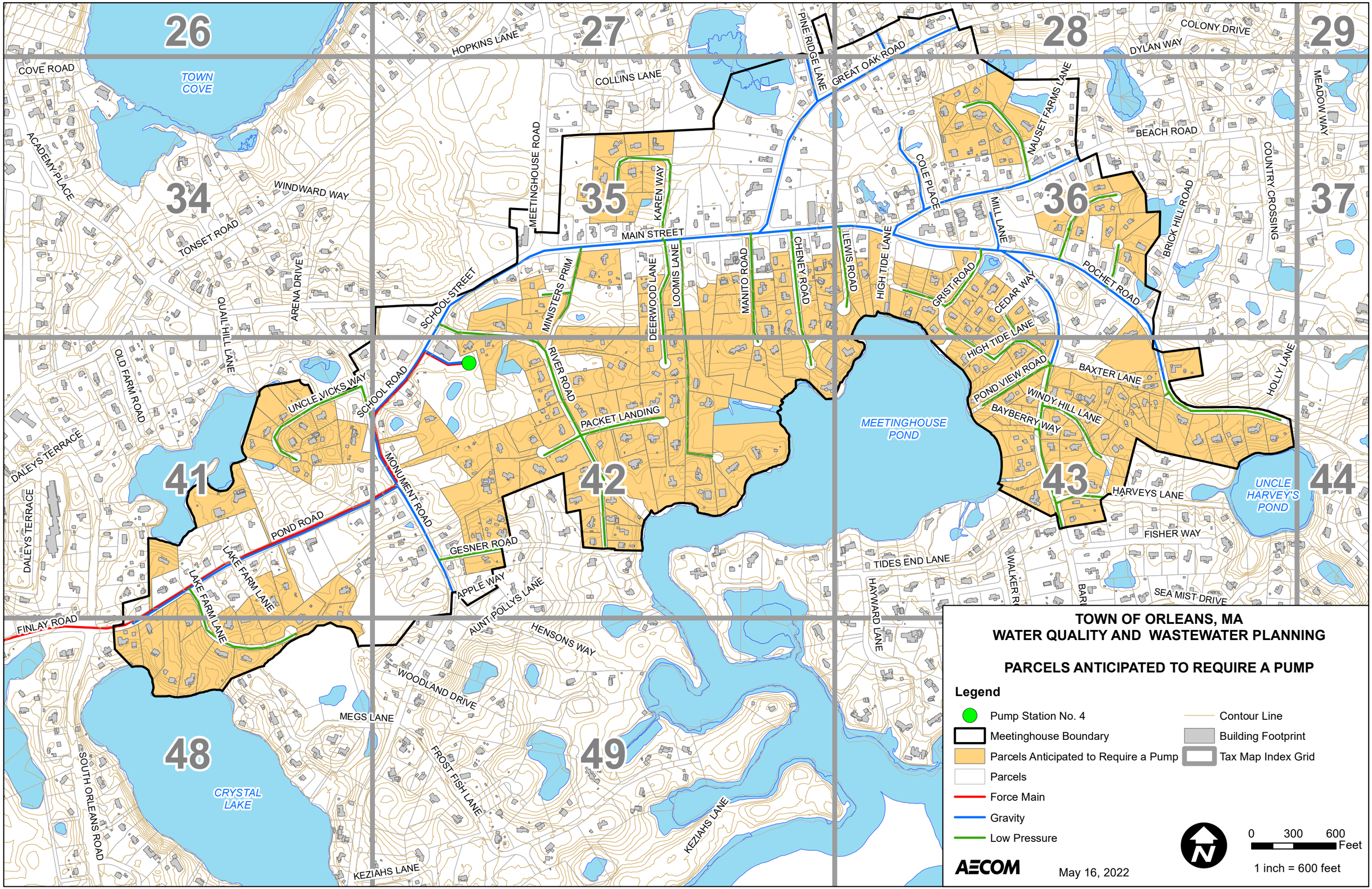
Town Cove

BREWSTER

ORLEANS

EASTHAM

CHASE LANE
FRONTAGE ROAD
ELS ROAD
HARBOR HILL ROAD
CAPTAIN DOANES WAY
ROUTE 6
CEDAR POND ROAD
JONES ROAD
CANAL ROAD
LOCUST ROAD
LIBERTY LANE
MAIN STREET
OLD COUNTY ROAD
COTTAGE STREET
ROUTE 6A
OLD COLONY WAY
KINGS WAY
CHILDS HOMESTEAD ROAD
ROUTE 28
COVE ROAD
DOANE TERRACE
CUMMINGS ROAD
BREWSTER CROSS ROAD
CENTER PLACE
ACADEMY PLACE
OLD STAGE ROAD
WEST ROAD
OAK RIDGE LANE
BOG HOLLOW ROAD
RAMP RT 6 WB TO RT 6A
RAMP RT 6A TO RT 6 EB
LOTS HOLLOW ROAD
ELDREDGE PARK WAY
NICKERSON ROAD
OLD FARM ROAD
TONSET ROAD
SCHOOL ROAD
LONGVIEW DRIVE



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TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING

PARCELS ANTICIPATED TO REQUIRE A PUMP

Legend

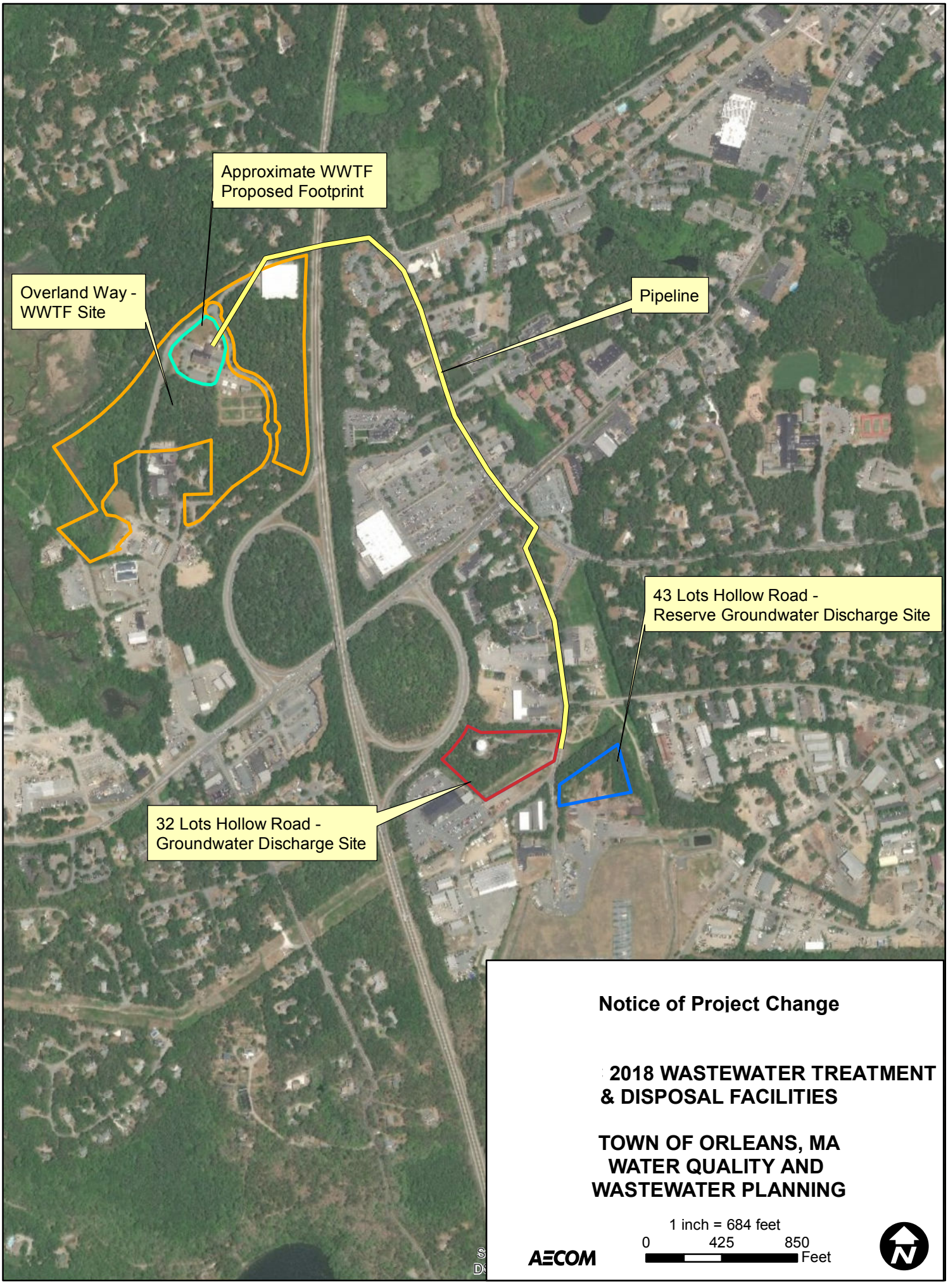
- Pump Station No. 4
- Meetinghouse Boundary
- Parcels Anticipated to Require a Pump
- Parcels
- Force Main
- Gravity
- Low Pressure
- Contour Line
- Building Footprint
- Tax Map Index Grid

AECOM

May 16, 2022

0 300 600 Feet

1 inch = 600 feet



Notice of Project Change

2018 WASTEWATER TREATMENT & DISPOSAL FACILITIES

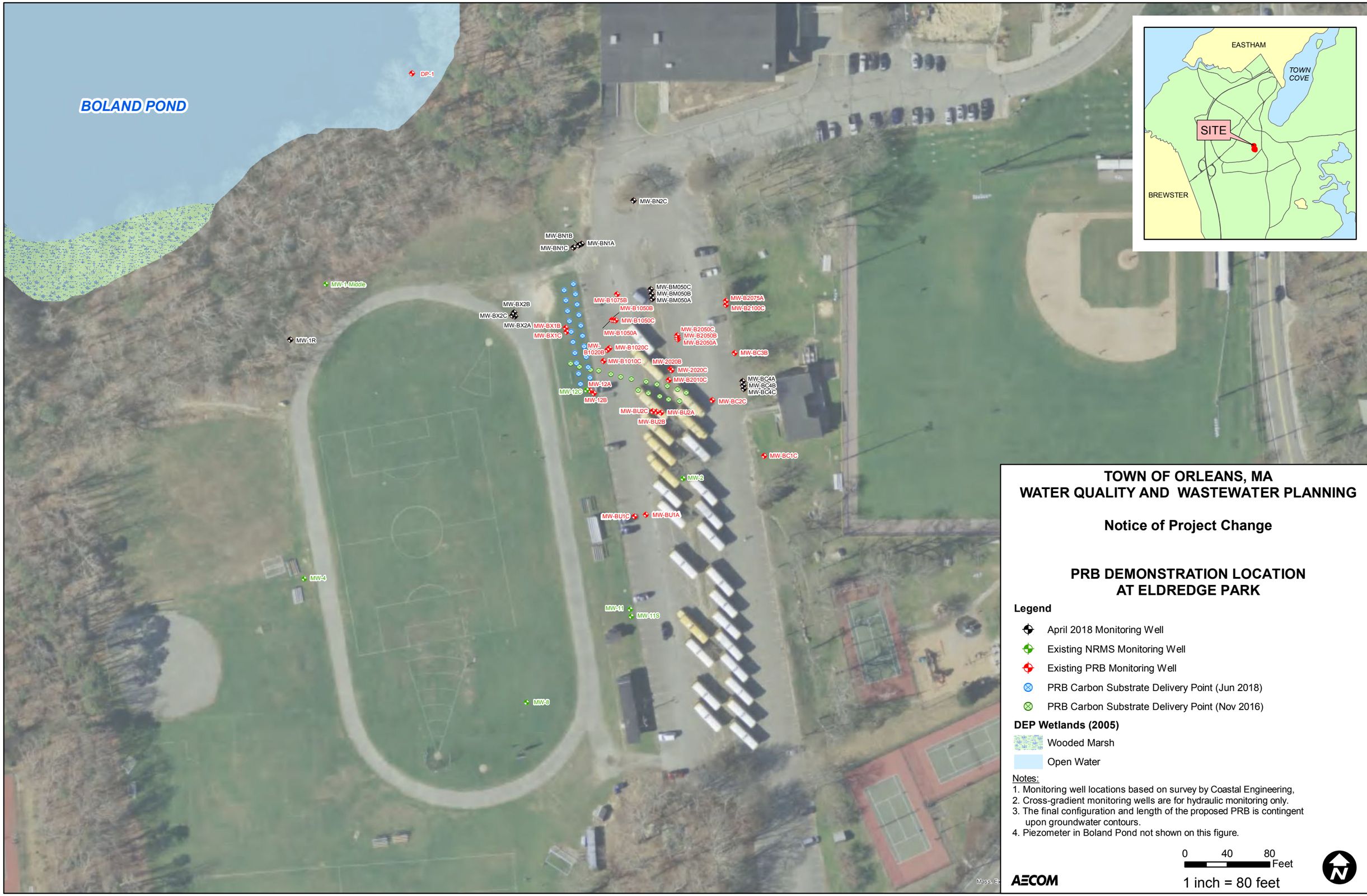
TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING

1 inch = 684 feet

0 425 850 Feet

AECOM

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TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING

Notice of Project Change

PRB DEMONSTRATION LOCATION AT ELDREDGE PARK

Legend

- April 2018 Monitoring Well
- Existing NRMS Monitoring Well
- Existing PRB Monitoring Well
- PRB Carbon Substrate Delivery Point (Jun 2018)
- PRB Carbon Substrate Delivery Point (Nov 2016)

DEP Wetlands (2005)

- Wooded Marsh
- Open Water

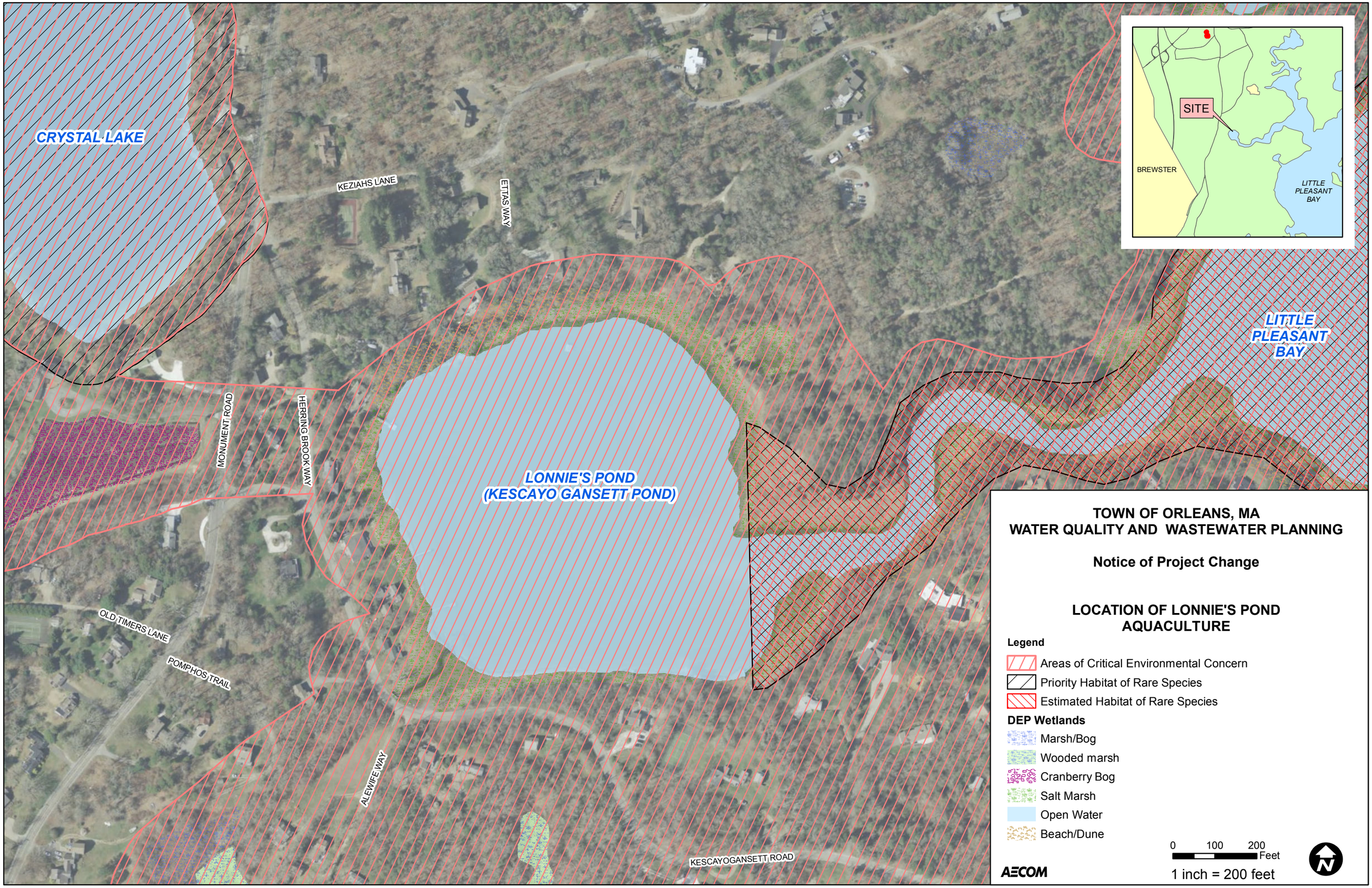
Notes:
1. Monitoring well locations based on survey by Coastal Engineering,
2. Cross-gradient monitoring wells are for hydraulic monitoring only.
3. The final configuration and length of the proposed PRB is contingent upon groundwater contours.
4. Piezometer in Boland Pond not shown on this figure.

0 40 80 Feet

1 inch = 80 feet

AECOM

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TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING

Notice of Project Change

LOCATION OF LONNIE'S POND AQUACULTURE

Legend

- Areas of Critical Environmental Concern
- Priority Habitat of Rare Species
- Estimated Habitat of Rare Species

DEP Wetlands

- Marsh/Bog
- Wooded marsh
- Cranberry Bog
- Salt Marsh
- Open Water
- Beach/Dune

0 100 200 Feet

1 inch = 200 feet

AECOM

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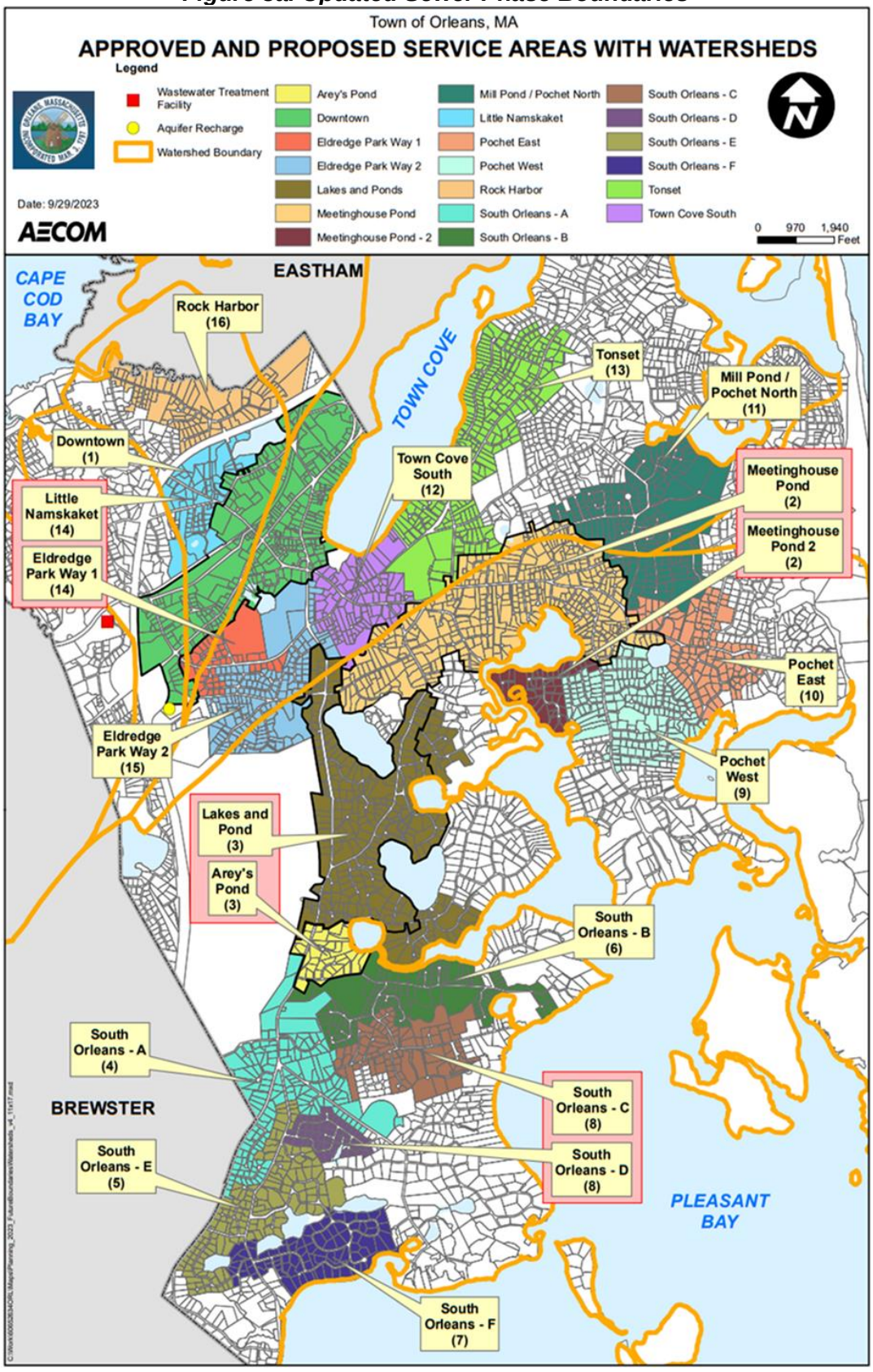
ATTACHMENT 3

CURRENTLY PROPOSED BUILD CONDITION

Table 3a. Updated Sewer Phases

Phase	Name	Pump Stations	Gravity Sewer	Low Pressure	Force Main	Approximate Sewer Length (miles)
3	Lakes and Ponds	Finlay Rd	X	X	X	7.5
4	South Orleans - A	Harwich Rd.	X	X	X	3.8
5	South Orleans - E	Lake Dr.	X	X	X	3.4
6	South Orleans - B	Namequoit Rd.	X	X	X	3.4
7	South Orleans – F	Towhee Ln.	X	X	X	2.5
8	South Orleans – C & D	Indian Fort Hill (C) Aunt Abigail's Way (D)	X	X	X	3.7
9	Pochet West	Fox Ridge Dr	X	X	X	4.2
10	Pochet East		X	X		1.8
11	Mill Pond/Pochet North	Great Oak Rd.	X	X	X	3.7
12	Town Cove South		X	X		1.4
13	Tonset		X	X		4.0
14	Eldredge Parkway 1 & Little Namskaket		X	X (Little Namskaket)		2.5
15	Eldredge Parkway 2		X			3.1
16	Rock Harbor	Rock Harbor Rd.	X	X	X	2.5
					Total	47.5

Figure 3a. Updated Sewer Phase Boundaries



Norseman

Duck Hole

Nauset Middle School
PRB Demonstration
Project Location

Mayflower

Lockwood

EASTHAM

BREWSTER

HARWICH

Town Cove

Mill Pond

Crystal Lake

The River

Pilgrim Lake

Little Pleasant Bay

Sampson Island

Hog Island

Sipson Island

Pleasant Bay

Rock Harbor

Orleans

East Orleans

South Orleans

Weeset

Tonset

Nauset Heights

POTENTIAL PRB LOCATIONS

Legend

Permeable Reactive Barrier

Capture Zone Flow Paths

0 1,000 2,000 Feet

1 inch = 2,000 feet

AECOM

Date: 11/6/2023

Sources: Esri, HERE, Garmin, USGS, Intermap, INCRE
(Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) Op
Community

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ATTACHMENT 4

USGS MAP


EASTHAM
EASTHAM
BREWSTER
HARWICH
CHATHAM
Nauset Harbor
Mill Pond
Town Cove
Pilgrim Lake
Crystal Lake
Baker Pond
Cliff Pond
Little Pleasant Bay
Little Pleasant Bay
Namequoit River
Jamesons Island
Minister Island
Minister Creek
Nauset Beach
Nauset Heights
Meeting House Pond
Uncle Seths Pond
Scraggy Pond
Arcuit Pond
Old Field
Tidal Flat
Town Landing
Town Landing
Town Landing

ATTACHMENT 5

NPC DISTRIBUTION LIST

NPC Distribution List
Amended Comprehensive Wastewater Management Plan

The document will be emailed to all recipients for whom an email address is available, and a hard copy will be mailed to those for whom no email address is provided.

Individual/Agency	Email Address
Alan McClennen, JR. FAICP	alanboats@aol.com
Ben A. Buck	Bn_buck@yahoo.com
Beverly M. Carney	38 Longview Drive Orleans, MA 02653
Boston Commissioners Office MassDEP	Helena.boccadoro@mass.gov
Brian and Judy Embleton	26 Ellis Road Orleans, MA 02653
Cape Cod Commission	ksenatori@capecodcommission.org regulatory@capecodcommission.org
Clean Water Action	cwa@cleanwater.org
David Farquhar	PO Box 868 East Orleans, MA 02643
Division of Marine Fisheries, New Bedford (Christopher Schillaci or other)	Marine.fish@mass.gov
Eastham Board of Selectmen c/o Jacqui Beebe	jbeebee@eastham-ma.gov
Kevin Cassidy	PO Box 2618 Orleans MA 02653
Mary Hartley	15 Salty Ridge Road Orleans, MA 02653
Massachusetts Department of Conservation and Recreation	Andy.backman@mass.gov
Massachusetts Department of Energy Resources	Paul.ormond@mass.gov
Massachusetts Department of Public Health	dphtoxicology@massmail.state.ma.us
Massachusetts Division of Fisheries, Wildlife, Natural Heritage and Endangered Species Program	Melany.cheeseman@mass.gov Emily.holt@mass.gov

Massachusetts Division of Marine Fisheries – South Shore	DMF.EnvReview-South@mass.gov
Massachusetts Historical Commission	MA Archives Building 220 Morrissey Boulevard Boston, MA 02125
Massachusetts Office of Coastal Zone Management	Sean.duffey@mass.gov Patrice.bordonaro@mass.gov Todd.callaghan@mass.gov
MassDEP Southeast Regional Office	George.zoto@mass.gov Jonathan.hobill@mass.gov
MassDEP Waterways	Ben.lynch@mass.gov dep.waterways@mass.gov
MassDOT District #5 Office	Cindy.McConarty@dot.state.ma.us
MassDOT, Boston	MassDOTPPDU@dot.state.ma.us
MEPA Office	MEPA@mass.gov
Orleans Pond Coalition c/o Frances McClennen, Vice President	Fran_mcclennen@yahoo.com
Pleasant Bay Alliance c/o Carole Ridley, Coordinator	cr@ridleyandassociates.com
Sierra Club – Massachusetts Chapter	chapter@massachusetts.sierraclub.org ddow42@comcast.net
Snow Library	67 Main Street Orleans, MA 02653
Town of Brewster	2198 Main Street Brewster, MA 02631
Town of Brewster c/o Peter Lombardi, Town Manager	townadmin@brewster-ma.gov
Town of Orleans Board of Health	Joseph.hartung@gibsonsir.com
Town of Orleans Board of Selectmen c/o Kimberly Newman	knewman@town.orleans.ma.us
Town of Orleans Conservation Commission	conservation@town.orleans.ma.us
Town of Orleans Planning Board c/o George Meservey, Director of Planning and Community Development	gmeservey@town.orleans.ma.us
Victoria L. Reis	30 Chase Lane Orleans, MA 02653



Amended Comprehensive Wastewater Management Plan

Prepared For:
Town of Orleans, MA
19 School Road
Orleans, MA 02653

Prepared By:
AECOM Technical Services, Inc.
9 Jonathan Bourne Drive
Pocasset, MA 02559

December 2023

Delivering a better world

Photo Credits

Front Cover: Pleasant Bay, George Meservey, Orleans Director of Planning and Community Development

Back Cover: Lonnie's Pond Aquaculture, George Meservey, Orleans Director of Planning and Community Development

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Attachment B	CCC Approval of The Town of Orleans CWMP as A DRI
Attachment C	Orleans Water Quality Advisory Panel Consensus Plan
Attachment D	Response to Comments
Attachment E	Minutes of September 2023 Pre-Filing Meeting with MassDEP and Cape Cod Commission
Attachment F	MassDEP Approvals for Lots Hollow Rd, Route 6 Clover Leaf, And Beach Rd Hydrogeologic Investigations and The Overland Way WWTF Effluent Discharge Permit
Attachment G	Technical Memorandum – Site Characterization and Evaluation for Floating Constructed Wetlands
Attachment H	Technical Memorandum – Final Work Plan for Floating Constructed Wetlands
Attachment I	Technical Memorandum – Site Characterization and Evaluation for Aquaculture and Shellfish Propagation
Attachment J	Lonnie's Pond Aquaculture Management Plan
Attachment K	Technical Memorandum – Site Characterization and Evaluation for Permeable Reactive Barriers
Attachment L	Technical Memorandum – Preliminary Engineering Work Plan for Permeable Reactive Barriers
Attachment M	Technical Memorandum – Full-Scale Permeable Reactive Barriers Watershed Planning
Attachment N	Technical Memorandum – Full-Scale Permeable Reactive Barriers Watershed Planning Investigation
Attachment O	Technical Memorandum – Nitrogen Reducing Biofilters Feasibility
Attachment P	On-Site Denitrification Systems Summary Report
Attachment Q	2022 And 2023 Namskaket Marsh Monitoring Reports
Attachment R	Report on the Feasibility of Nitrogen Removal Credits
Attachment S	Eastham Memorandum of Understanding
Attachment T	Report on Nitrogen Trading Opportunities Among Watershed Towns
Attachment U	Climate Resilience Design Standards Tool Project Reports
Attachment V	Environmental Justice Advanced Notification

1. Executive Summary

The Town of Orleans (Town) continues to build on efforts to improve water quality in its coastal estuaries and freshwater ponds. This document amends the Town's previous Comprehensive Wastewater Management Plan (CWMP) based on additional studies and wastewater engineering and planning decisions that have occurred since the publication of the CWMP/Single Environmental Impact Report (SEIR) in 2010 (Wright-Pierce, 2010). Since the CWMP was approved by the Town in 2011, the Town has allocated funds each year through the Town Meeting process to advance the planning and implementation of agreed-upon solutions and projects. Several boards, subcommittees, and working groups were formed and met over the years with various consulting firms to guide the process to achieve consensus on a plan that would be approved by Town residents. This document reflects the progress and modifications that have been made to the CWMP since 2010. Input gathered from stakeholders over the years has produced a range of information, suggestions, and opinions regarding the types of traditional sewering technologies, the frequency of their use, and where these technologies would be most appropriate and effective. In addition, these discussions identified the potential for using a number of Non-Traditional (NT) Technologies to reduce nitrogen loads into receiving waters. This Amended CWMP (ACWMP) updates the Town of Orleans approach to wastewater management and nutrient reductions based on work since 2010. The ACWMP is an elaboration on and natural evolution of the original CWMP.

Since 2010, the Town has updated planned sewer service areas and proposed sewer phases. The 2023 service areas correspond to the 2010 CWMP "Core Area," but the time period for completing sewer installation in these areas has been extended through 2067 due to multiple considerations (including the Town's need to address other financial needs and continuing studies). The recommendation for sewer phases to increase from six to sixteen is intended to provide more financial flexibility and more opportunities for adaptive management. The phasing approach has prioritized sewering for areas tributary to Pleasant Bay, which is currently subject to a total maximum daily load (TMDL) and covered by a Watershed Permit, of which Orleans is one of four permittees. Also, in 2022 the Town installed updated modern water meters, which allow for accurate water use tracking and projecting of future wastewater flows and began collecting Town-wide data in Fiscal year (FY) 2022 (July 1, 2021-June 30, 2022). The Town completed construction of the new wastewater treatment facility (WWTF), which began operation in 2023. The first phase of sewering has also been completed in the "Downtown" area, which includes the business district and some residential properties along the Route 6A and Old Colony Road corridors. Approximately 5,000 kilograms of nitrogen per year (kg N/year) are projected to be removed as a result of Phase 1. Construction of Phase 2 around much of Meetinghouse Pond is currently underway. Approximately 2,000 kg N/year are projected to be removed as a result of Phase 2. At the Fall 2023 Town Meeting, the Town voted to expand Phase 2 to include Tides End Lane as an additional step towards meeting the Town's requirements for nitrogen removal from the Pleasant Bay watershed.

Non-traditional (NT) Technologies were mentioned in the 2010 Plan and further expanded upon during subsequent planning efforts. NT Technologies evaluated since the 2010 CWMP include permeable reactive barriers (PRBs), floating constructed wetlands (FCWs), shellfish aquaculture, and on-site innovative alternative systems (I/A), including nitrogen-reducing biofilters (NRBs). Each of these technologies was evaluated through a detailed process, including the development of a work plan, site selection, conceptual design, costs, regulatory considerations, and potential funding. At the conclusion of the NT evaluation process, PRBs and aquaculture were selected for demonstration project implementation. Based on the results of the demonstration projects, the Town has decided to include these two NT Technologies in its wastewater management and nutrient control strategy. Aquaculture has been implemented at Lonnie's Pond since 2019. A PRB demonstration project has been underway at Eldredge Park since 2016. Additional PRB investigations and evaluations are planned to facilitate PRB implementation at four locations elsewhere in Town.

The 2010 CWMP/SEIR identified and explained the Town's iterative approach to managing wastewater and stormwater, which was identified as Adaptive Management. The 2010 CWMP indicated that the

Town's approach would be evaluated for effectiveness based on water quality monitoring, nitrogen removal effectiveness, and updates to the Massachusetts Estuaries Project (MEP). The Amended CWMP continues to incorporate an Adaptive Management approach to address potential future changed conditions, new information that becomes available from ongoing studies, potential growth impacts, and other considerations. The Adaptive Management Plan Approach included in the Amended CWMP also discusses the following:

- Future growth in the Town of Orleans
- The Pleasant Bay Alliance Watershed Permit
- Ongoing water quality monitoring
- The Pochet Neck Nitrogen Attenuation Study currently underway
- Namskaket Marsh monitoring
- Freshwater Ponds nutrient management
- Stormwater and fertilizer management programs
- Regional coordination with both Eastham and Brewster

The Town intends to implement water quality improvement measures using an Adaptive Management approach. Adaptive management is a tool for continued refinement of the ACWMP to optimize the individual components (e.g., specific type, size, and location of control technologies) to contribute to the cost-effective achievement of nutrient load reduction goals. Through the Adaptive Management approach, the Town will continue to take into account the cost, environmental impact, and acceptability of the plan to the residents and the businesses of Orleans.

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

The Massachusetts Department of Environmental Protection (MassDEP) Comprehensive Wastewater Management Planning process includes an evaluation of current and future wastewater needs, identification of wastewater management alternatives, and the development of recommended strategies. The Comprehensive Wastewater Management Plan should reflect the input of local, regional, and state stakeholders and allow the Town to identify the most environmentally appropriate and cost-effective strategies to meet wastewater management needs at a Town-wide scale. In 2010, a CWMP was prepared for the Town of Orleans that proposed to meet state and federal mandates through an expansion of a future municipal sewer system under an Adaptive Management approach. An updated Section 208 Plan was prepared by the Cape Cod Commission (CCC) and approved by the Massachusetts Department of Environmental Protection and the U.S. Environmental Protection Agency (EPA) in 2015, which included recommendations for improving water quality and identified potential alternative technologies to achieve water quality improvements. Following this, a Consensus Agreement was developed by the Town. The Consensus Agreement led to the preparation of this Amended CWMP (ACWMP), which was developed to provide the Town of Orleans with an alternative, more cost-effective strategy for managing wastewater and reducing nitrogen in the Pleasant Bay, Rock Harbor, and Nauset Harbor watersheds. This ACWMP summarizes the results of actions and studies since 2010 and outlines the Town's updated approach to wastewater management.

2.1 Project History – 2010 CWMP/SEIR

The Town of Orleans prepared a CWMP and Single Environmental Impact Report (SEIR) in December 2010. The 2010 CWMP/SEIR defined the need for nitrogen control and proposed a new centralized sewer system to reduce nitrogen loads into the coastal bays and estuaries of Orleans. The 2010 CWMP proposed a municipal system that would serve over half of the properties in Orleans and cost an estimated $150 million over 15 to 20 years. The CWMP included an extensive needs assessment, which did not support town-wide sewers.

Alternative scenarios were evaluated to determine the optimal nitrogen removal plan for the Town and region. The 2010 Plan referenced potential types of NT Technologies to remove nitrogen. These Technologies improve water quality through one or more of the following pathways:

- Preventing future nitrogen loads;
- Reducing current nitrogen loads before they reach the groundwater;
- Taking advantage of the natural processes that impact groundwater quality as nitrogen moves toward the embayments – also known as "attenuation";
- Improving the ability of the embayment to assimilate nitrogen loads; and
- Removing nitrogen from the water column or sediments within the embayments

Ultimately, the wastewater plan that was selected in 2010 relied solely on traditional collection, treatment, and disposal systems and did not incorporate NT Technologies as NT Technologies are often not cost-effective. The CWMP proposed a core of sewers supplemented by non-structural options and use of NT systems as more became known about their capability and cost.

Key recommendations of the 2010 CWMP/SEIR included 74 miles of new sewer lines, 63 sewer pump stations, and a new wastewater treatment and groundwater disposal facility at the former Tri-Town Septage Treatment Facility (TTSTF) site, capable of treating up to 640,000 gallons of wastewater per day (gpd). 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 2010 CWMP recommended five cluster systems, these five small local treatment and disposal facilities were intended to provide early protection of certain threatened

receiving waters. The cluster systems were chosen to incorporate a more focused and rapid removal of nitrogen and phosphorus in certain areas. Four cluster systems were identified to serve neighborhoods that are in the watershed of an impacted coastal embayment and the fifth cluster system was identified to serve the watershed of a freshwater body.

The Cape Cod Commission held a joint hearing with the Massachusetts Environmental Policy Act Office (MEPA) staff on January 18, 2011, regarding the Environmental Impact Report (EIR). 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/SEIR (**Attachment A**) stating that the project complied with MEPA. This action started the timeline for the CCC to hold their first public hearing to review the project within 45 days of the Certification. Several additional hearings were held between March and October 2011. On October 13, 2011, the CCC voted unanimously to approve the project and issued a Development of Regional Impact (DRI) with conditions approval (see **Attachment B**). The DRI approval included conditions regarding the potential of operating the Orleans Wastewater Treatment Facility as a shared municipal facility, but also allowed Orleans to proceed with a single-town facility 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 wastewater treatment facility discharge.

2.2 Cape Cod Commission 208 Plan Update Recommendations

Due to the impairment of water quality in coastal waters from excess nitrogen, MassDEP directed the Cape Cod Commission in 2013 to develop an update to the 1978 Water Quality Management Plan for the region, in accordance with Section 208 of the Federal Clean Water Act. The CCC issued the updated 208 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, including potential NT Technologies to achieve water quality improvements. These recommendations were considered by the Town of Orleans in their subsequent wastewater planning process. The recommendations were designated to one of four categories:

- **Information**
    - Recommendations regarding improvement of water quality monitoring and data management, implementation of NT Technologies, and evaluation of septage processing demands
- **Regulatory Reform**
    - Recommendations for revisions to CCC and MassDEP procedures and guidelines for preparing and reviewing watershed management plans
- **208 Support**
    - Recommendations for additional tools and technical expertise from the CCC and that the CCC provide additional guidance and resources to communities to assist in planning and implementing nitrogen reduction measures, including assistance with stakeholder consensus building
- **Cost**
    - Recommendations for the provision of additional funding from the CCC, the Commonwealth, and the Federal Government

2.3 2015 Consensus Agreement & Orleans Water Quality Advisory Panel

In 2014, the Orleans Water Quality Advisory Panel (OWQAP) convened to achieve consensus and build widespread community support for a customized, affordable Water Quality Management Plan for the

Town. The panel included stakeholder representatives (Orleans Select Board Members 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 between 2014 and 2016, all of which were open to public attendance and comment and were professionally facilitated. The goals of the OWQAP were as follows:

- Consolidate the information being provided through the various studies being performed;
- Provide a forum for obtaining information, advice, and opinions from businesses, residents, and advocacy groups of the Town;
- Assist in reporting to the broader voting public on the results and plans for future actions with respect to water quality and wastewater planning; and
- Achieve consensus so that Water Quality and the Wastewater Management Plan could move forward.

The OWQAP reviewed potential alternative planning scenarios to meet water quality standards that were presented at meetings and workshops. During an OWQAP public workshop on December 17, 2014, a "Hybrid Plan" to reduce nitrogen was presented and reviewed. This plan described a combination of traditional and NT Technologies that met the MassDEP, TMDL, and Massachusetts Estuaries Project (MEP) load-reduction targets for nitrogen in each impaired waterbody (although the NT Technologies may not have allowed TMDL compliance). Three OWQAP subgroups were formed to discuss, evaluate, and revise the Hybrid Plan.

To assist in the evaluation process, the OWQAP utilized a Technology Evaluation Decision Support Tool that allowed the risks and benefits of each technology to be evaluated at the sub-watershed level based on a number of ranked parameters. Preliminary comparative costs were also presented on a relative dollars/kilogram of nitrogen removed basis. The result was an Evaluation Matrix that summarized the risks and benefits of each technology. The Matrix was comprised of the following 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 removal
- Overall cost

The resulting revised Hybrid Plan described two general areas for sewers. The first area included approximately 270 parcels encompassing Downtown Orleans, which lies within the Town Cove Sub-Watershed of the Nauset Harbor Watershed and partially within the Rock Harbor Watershed. This area was 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 Sub-Watershed of the Pleasant Bay Watershed. This area was estimated to generate 50,000 gpd, which would be treated at a new satellite treatment facility and groundwater effluent disposal area. The Hybrid Plan also listed specific sites for the potential use of NT Technologies to remove nitrogen. The number of acres of shellfish growing area, linear feet of PRBs, and square footage of FCWs necessary to achieve specific nitrogen-removal targets were quantified. This exercise was undertaken to confirm that the quantities of all NT Technologies proposed were feasible to install at specific locations and became the basis for potential demonstration site locations, but the OWQAP exercise did not confirm the extent of NT Technologies needed.

The Hybrid Plan was vetted through the OWQAP during three meetings, including a day-long workshop. This iterative process resulted in a Draft Consensus Agreement that included a combination of traditional

and NT Technologies. Once the feasibility of using NT Technologies as part of the Town's nutrient management strategy was established, the OWQAP decided that the final Consensus Agreement (Attachment C) would not specify exact locations for these Technologies but instead focus on the overall area needed to remove the appropriate mass of nitrogen at the watershed level. The final Consensus Agreement, dated March 16, 2015, details the agreed upon water quality goals, objectives, and Water Quality Management Plan approach and key elements. OWQAP continued to meet and report on progress until 2017. As discussed below, after the OWQAP Consensus Agreement, non-traditional Technologies were further evaluated, and some were dismissed from consideration.

2.4 2.4 MEPA Notices of Project Change

On October 30, 2018, AECOM submitted a Notice of Project Change (NPC) on behalf of the Town of Orleans to MEPA in accordance with 301 CMR 11.10(1). The 2018 NPC described two new sites for effluent disposal – 32 & 43 Lots Hollow Road. It also described the construction of new effluent force main sewers and explained that construction would be done in phases for the Wastewater Treatment Facility (WWTF) at Overland Way. The 2018 NPC indicated that land alteration would be decreased with the newly selected disposal site and permanent impacts to NHESP Rare Species and Critical Habitat would be avoided. MEPA approval was received on December 7, 2018. The Certificate stated that an environmental impact report (EIR) was not required, and that further MEPA review was not needed.

On March 15, 2019, a second NPC was submitted to the MEPA Office in accordance with 301 CMR 11.10(1). The 2019 NPC indicated that the Town was planning to incorporate two demonstration projects into the wastewater management planning process: a Permeable Reactive Barrier (PRB) at Eldredge Park and oyster aquaculture in Lonnie's Pond. Demonstration projects for these NT Technologies were initiated in 2016. Monitoring has been ongoing since implementation to evaluate their effectiveness. On April 19, 2019, MEPA issued a Certificate of the Secretary of Energy and Environmental Affairs, which stated the 2019 NPC did not require an EIR and that no further MEPA review was required.

Comments received and summarized responses for each NPC are provided in **Attachment D** of this Amended CWMP. Certificates are provided as **Attachment A**.

2.5 Wastewater Management Advisory Committee (WMAC)

The Wastewater Management Advisory Committee was formed in 2022 to continue work on the Orleans Wastewater Management Project. The members of this committee include members from Town Boards, Committees, and Commissions. The Committee is charged with completing the following tasks:

- Review past documents to gain a working knowledge of relevant studies and reports on key decisions and project milestones that may have a bearing on wastewater management;
- Identify, complete, and submit the required CWMP amendments in a timely manner;
- Develop an understanding of work completed on alternative wastewater technologies that were recommended in the 2015 Consensus Agreement and have been evaluated since that time;
- Develop an understanding of regulatory requirements to preserve and protect marine and freshwater bodies within the Town;
- Determine if further investigation is needed on alternatives;
- Develop a decision-making process for weighing the relative value, costs, and benefits of alternative technologies compared to traditional sewers for each watershed over time;
- As part of the decision-making process, include public outreach and feedback;
- As part of the decision-making process, work with the Town Manager and Finance Director on the long-range capital planning schedule taking into account the Town debt schedule in an effort to maintain a stable tax rate; and

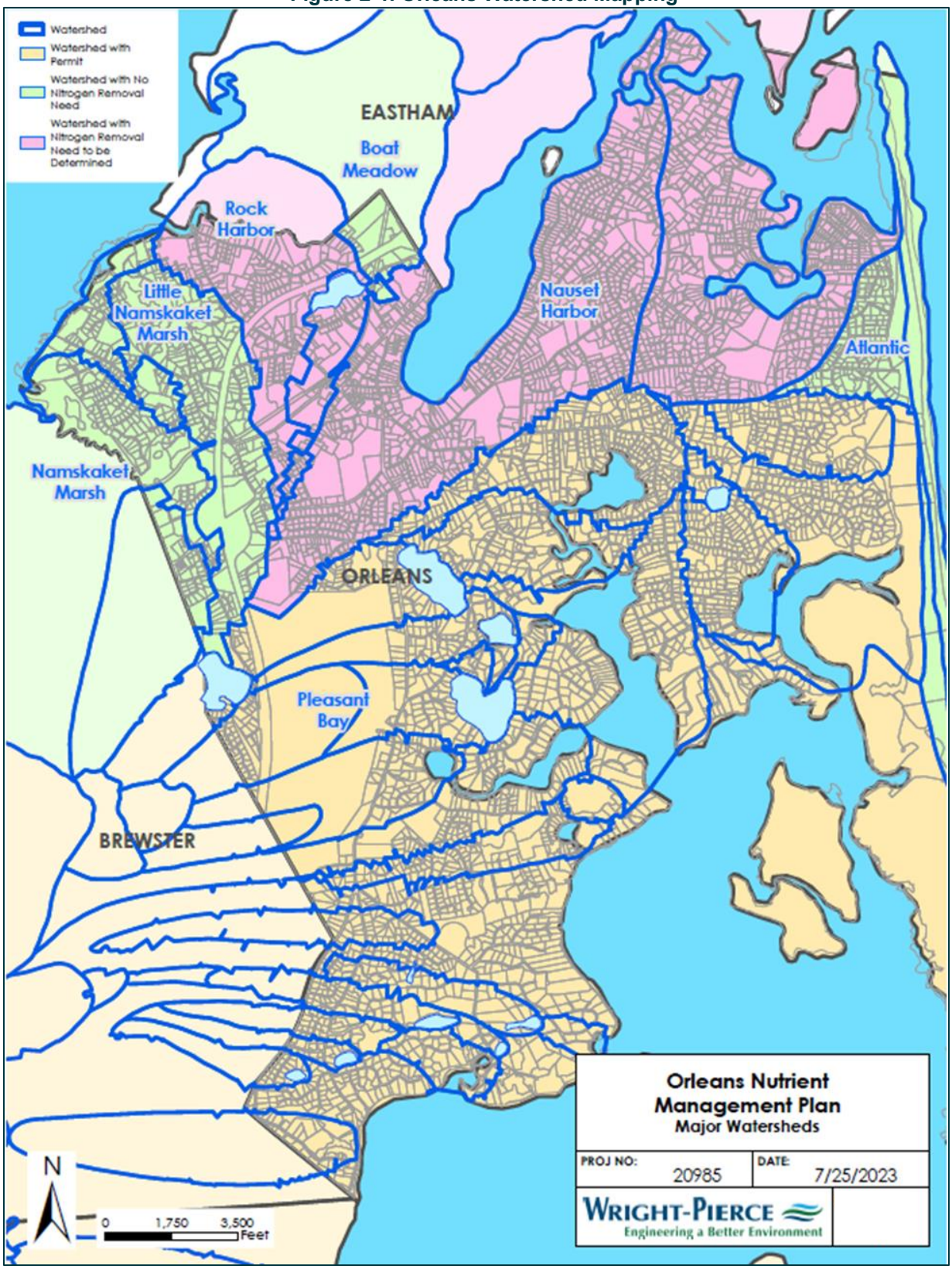
- Provide quarterly updates to the Select Board on the recommended future sewer phases and/or permanent alternative technologies to meet MassDEP requirements for water quality restoration.

2.6 Amended CWMP

This Amended CWMP (ACWMP) builds upon earlier studies and data collection completed for the 2010 CWMP/SEIR and subsequent NPCs and studies. The ACWMP provides an update on the additional planning and engineering efforts that were completed since its approval in 2011 and describes the Town of Orleans' plans to meet water quality and habitat restoration goals. Existing TMDLs and MEP publications were used as a guideline for nitrogen removal targets that will assist in meeting water quality and habitat restoration goals. A combination of sewering, aquaculture, and PRBs is proposed to meet these nitrogen removal goals as described in subsequent sections of this document.

The Town's approach to estimating nitrogen removal is based on water use data and a planning level estimate of 4 kg of nitrogen removal per developed parcel, which is further explained below in Section 3.2. **Figure 2-1**, developed by Wright-Pierce, displays the watersheds of Orleans and their nitrogen removal needs. Orleans is prioritizing water quality improvement infrastructure in the Pleasant Bay watershed, where there are TMDLs established for19 sub-embayments of the estuary and an executed Watershed Permit. The Pleasant Bay watershed is additionally designated as a "Nitrogen Sensitive Area" (NSA) based on the 2023 updated Title 5 septic system regulations (310 CMR 15.000: Septic Systems ("Title 5")) and Watershed Permit regulations (314 CMR 21.00: Watershed Permit Regulations). The other watersheds in Orleans are not designated NSAs. The TMDL for the Nauset watershed had not been established yet due to the need for revised water quality modeling. Realistic nitrogen load reductions have yet to be developed. It is understood that the Nauset Harbor and Rock Harbor embayments will not be designated as NSAs under Title 5 at this time (**Attachment E**).

Figure 2-1. Orleans Watershed Mapping



3. Traditional Wastewater Infrastructure

The 2010 CWMP identified the need for a sewer collection system throughout a significant portion of the Town, a new wastewater treatment facility, and an effluent disposal site. The construction of the new 350,000 gallons per day (gpd) WWTF began in 2020 and was substantially completed in March 2023. This section provides a summary of disposal site investigations and the completed effluent disposal facility, as well as the planned and completed sewering. Traditional wastewater collection, treatment, and disposal is proposed for the Town of Orleans "core" area, as initially described in the 2010 CWMP and further refined since then, as discussed below in Section 3.2. **Table 3-1** compares the 2010 and 2023 CWMPs for Wastewater Collection, Wastewater Treatment, and Effluent Disposal. The design capacity identified in this ACWMP is 700,000 gpd, which is greater than the predicted flow based on current development (see **Table 3-5** in Section 3.2), in order to allow for future growth as well as an allowance for variation in water usage in future years. In addition, the current 350,000 gpd WWTF is designed such that it can easily be doubled in capacity from an operational perspective.

Table 3-1. CWMP Comparisons

		2010 CWMP	2023 ACWMP
Properties Served by Wastewater Collection	Pleasant Bay Watershed	1,680	1,755
	Nauset Watershed	880	914
	Rock Harbor Watershed	270	311
	Total	2,800	2,980
Length of Sewers		390,000 linear feet	255,974 linear feet
Total Number of Pump Stations		140	12
Wastewater Treatment Design Annual Average Flow		640,000 GPD	700,000 GPD
Effluent Disposal Method		Rapid Infiltration at Wastewater Treatment Facility	Wick Wells at 32/43 Lots Hollow Road*

*The existing wick wells at 32/43 Lots Hollow Road are sufficient through approximately 500,000 gpd discharge flow, which is predicted to be exceeded after Phase 12 in approximately 2055, at which time additional discharge locations will be needed

3.1 Disposal Site Investigations

The 2010 CWMP identified that effluent recharge was planned to occur at the proposed WWTF site on Overland Way via a series of ten open rapid infiltration basins at the former Tri-Town Septage Treatment Facility. The Town re-evaluated effluent recharge options between 2015 and 2018. The following ten alternative sites were investigated for potential discharge of the treated effluent to groundwater:

- Water Tank (32/43 Lots Hollow Rd)
- Overland Way (Parcels 1/1A)
- Route 6 Interchange Exit 89 (Old Exit 12 Cloverleaf)
- Thayer Property (Orleans Market Place)

- Old Colony Apartments (Old Colony Way)
- Hole in One Restaurant Parking (Cranberry Highway)
- Depot Square (Old Colony Way)
- Orleans Elementary (46 Eldredge Park Way)
- Nauset Regional Middle School (70 Eldredge Park Way)
- Orleans Baseball Field (80 Eldredge Park Way)

During the investigation of additional alternative effluent discharge locations, an alternative approach for effluent discharge using wick wells was also evaluated and eventually selected. The smaller required footprint of the wicks compared to infiltration beds allowed consideration of smaller sites. After a site selection process, the 32 and 43 Lots Hollow Road, Beach Road, and Route 6 Exit 89 (Old Exit 12) Cloverleaf sites were selected for further investigation via Hydrogeologic Evaluations. The Town ultimately selected the Lots Hollow Road sites as the primary discharge location. The Overland Way and Route 6 Exit 89 (Old Exit 12) Cloverleaf alternative sites were selected as back-up recharge sites. The Hydrogeologic Evaluation Reports for 32 and 43 Lots Hollow Road were provided to the MassDEP Southeast Regional Office for review and comment regarding the suitability of these sites for effluent discharge. The report summarizes site investigations, data, and groundwater mounding analysis, as well as the results and conclusions of the evaluations. The groundwater modeling focuses on determining the maximum discharge capacity of each site and potential impacts from discharges. (AECOM, 2018a). Hydrogeologic Reports for Overland Way and the Route 6 Exit 89 (Old Exit 12) back-up recharge locations were previously approved in 2017 and 2019, respectively (**Attachment F**).

On October 30, 2018, AECOM submitted a Notice of Project Change (NPC) on behalf of the Town to the MEPA Office in accordance with 301 CMR 11.10(1). The 2018 NPC provided an update on a new proposed primary effluent recharge site from the Tri-Town Septage Facility to 32 Lots Hollow Road, with 43 Lots Hollow Road as a reserve site, and included the 2018 Hydrogeologic Evaluation Reports for 32 Lots Hollow Road and 43 Lots Hollow Road. Because the wick discharge requires considerably less area, the new effluent discharge at Lots Hollow Road results in disturbance to less acreage than the effluent discharge scenario originally proposed in the 2010 CWMP. In addition, the Lots Hollow sites are farther from sensitive Estimated and Priority Habitat mapped by the Massachusetts Natural Heritage and Endangered Species Program (NHESP) as compared to the 2010 CWMP site and are less archaeologically sensitive than the previously proposed location at Overland Way.

Approximately 0.91 miles of new WWTF effluent force main lines are required between the WWTF on Overland Way and the discharge locations at 32 Lots Hollow Road. The effluent pipeline exits the WWTF, located at the site of the now-demolished Tri-Town Facility, crosses Route 6, and then follows existing roads to the discharge site at Lots Hollow Road. The pipe was installed by open trench cut and cover methods including the crossing at Route 6.

The change to the wicks effluent recharge site from the originally proposed beds at Overland Way resulted in some changes to the groundwater flow and nitrate loading in sub-watersheds. The wick location results in residual nitrogen load to more sub-embayments than did the original rapid infiltration beds. Overall, the project still benefits water quality of receiving waters. **Table 3-2** and **Table 3-3** show the projected watershed loads at the Lots Hollow Road discharge sites for 5 and 10 mg/l of nitrogen discharge concentrations respectively, based on wick discharge rates ranging from 50,000 to 500,000 gpd. MassDEP approved the 32 and 43 Lots Hollow Road discharge location sites for a total of 500,000 gpd on May 9, 2019, after their review of the submitted Hydrogeologic Reports (**Attachment F**). In March 2020 MassDEP approved the groundwater discharge permit (GWDP) for the new WWTF on Overland Way, for an annual average flow of 350,000 gpd t (**Attachment F**) and subsequently approved a slight modification to the wick well design on September 27, 2021 (**Attachment F**). The GWDP requires that the wick wells be inspected after Phase 1 and before flow from Phase 2 is discharged; the Town plans to coordinate with MassDEP in 2025 regarding the wick wells and before Phase 2 is connected to the WWTF.

Some residents expressed concern over the decision to install wick wells on Lots Hollow Road with regard to the Town's drinking water supply. The Town of Orleans has eight groundwater wells that pump water from the Monomoy Lens, the second largest of six aquifers located on the Cape. Wells 1 through 6, and 8 are located on approximately 500 acres of Town-owned land off Route 28. Well 7 is located on approximately 38 acres of Town-owned land off Quanset Road. The Town of Orleans restricts any activities on these properties that could potentially contaminate the wells (Town of Orleans, 2020a). The wick well effluent discharge system will not affect drinking water. The drinking water wells are upgradient from the effluent discharge wick wells. The groundwater flows away from and not toward the drinking water wells. Additionally, MassDEP-mandated monitoring of all water supply wells (municipal or private) is ongoing and would identify any contamination to the drinking water supply.

Table 3-2. Projected Watershed Loads 5mg/L

		Estimated Watershed Load Mass Load (kg/yr) [1,2]							Percentage of Simulated WWTF Load						
Discharge Rate (GPD)	Wick Discharge Location	Cape Cod Bay	Namskaket	Little Namskaket	Rock Harbor	Boat Meadow Harbor	Town Cove	Other[3]	Cape Cod Bay	Namskaket	Little Namskaket	Rock Harbor	Boat Meadow Harbor	Town Cove	Other[3]
50,000	Lots Hollow Rd[4]	111	0	88	18	0	0	0	51%	0%	41%	8%	0%	0%	0%
150,000	Lots Hollow Rd[4]	302	1	203	63	1	3	0	53%	0%	35%	11%	0%	1%	0%
250,000	Lots Hollow Rd[4]	507	19	267	88	2	42	0	55%	2%	29%	9%	0%	5%	0%
350,000	Lots Hollow Rd[4]	700	78	312	108	4	145	0	52%	6%	23%	8%	0%	11%	0%
500,000	Lots Hollow Rd[4]	919	251	363	131	7	397	0	44%	12%	18%	6%	0%	19%	0%

Notes:

[1] Based on Steady State Flow.

[2] Model Simulation run for 40,000 days (109 years).

[3] Other Includes the Atlantic Watershed, Pleasant Bay Watershed, and drain cells to the east.

[4] Groundwater discharge in area of proposed wick locations

Table 3-3. Projected Watershed Loads - 10mg/L

		Estimated Watershed Load Mass Load (kg/yr) [1,2]							Percentage of Simulated WWTF Load						
Discharge Rate (GPD)	Wick Discharge Location	Cape Cod Bay	Namskaket	Little Namskaket	Rock Harbor	Boat Meadow Harbor	Town Cove	Other[3]	Cape Cod Bay	Namskaket	Little Namskaket	Rock Harbor	Boat Meadow Harbor	Town Cove	Other[3]
50,000	Lots Hollow Rd[4]	222	0	176	35	0	0	0	51%	0%	41%	8%	0%	0%	0%
150,000	Lots Hollow Rd[4]	603	1	405	126	1	5	0	53%	0%	35%	11%	0%	0%	0%
250,000	Lots Hollow Rd[4]	1,013	38	533	175	4	84	0	55%	2%	29%	9%	0%	5%	0%
350,000	Lots Hollow Rd[4]	1,399	156	624	216	8	289	0	52%	6%	23%	8%	0%	11%	0%
500,000	Lots Hollow Rd[4]	1,837	501	725	261	14	794	0	44%	12%	18%	6%	0%	19%	0%

Notes:

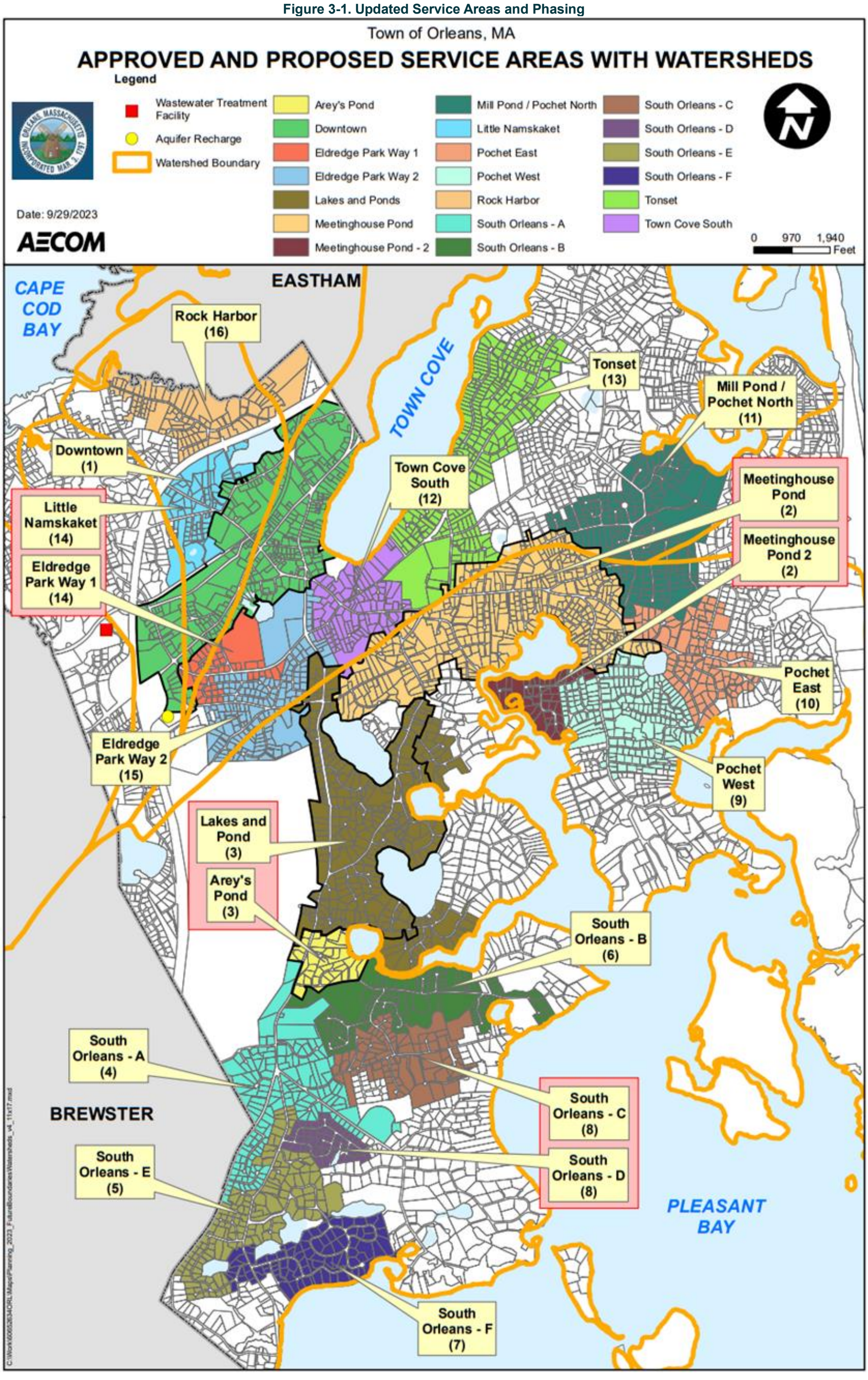
[1] Based on Steady State Flow.
[2] Model Simulation run for 40,000 days (109 years).
[3] Other Includes the Atlantic Watershed, Pleasant Bay Watershed, and drain cells to the east.
[4] Groundwater discharge in area of proposed wick locations

3.2 Updated Sewer Service Areas and Phasing Plan

The 2010 CWMP proposed construction of a wastewater collection system and new, centralized wastewater treatment facility over a 20-year period using six implementation phases. This construction included a 640,000 gpd WWTF at the former TTSTF site, 74 miles of sewer pipes, and 63 pump stations to treat 2,800 properties along the Pleasant Bay, Nauset Harbor, and Rock Harbor watersheds. The extent of this proposed sewer area is considered to be the “Core Area” of the sewer plan. The 2010 CWMP proposed employing an Adaptive Management approach which included compliance with TMDL requirements, monitoring for nitrogen reductions, and making changes to the CWMP as necessary in response to new data. It also included evaluation opportunities to accommodate additional wastewater flows from Eastham and/or Brewster.

As part of its wastewater master planning efforts, the Town has updated the sewer service areas. The 2023 updated service areas (**Figure 3-1.** Updated Service Areas and Phasing) correspond to the 2010 CWMP “core area”. Instead of six phases, the ACWMP assumes implementation of sixteen phases based on consideration of priorities for nitrogen removal as well as sewer connectivity and associated construction logistics. The updated service areas also provide the Town with flexibility for scheduling and combining areas, depending on funding availability and other Town priorities. As discussed below, the Town plans to extend the time period for sewering the Core Area through 2067. This is due to multiple considerations, including the Town’s need to address other financial needs and the continuing studies on PRBs and nitrogen attenuation, as discussed in subsequent sections of this Amended CWMP. The 2023 ACWMP includes fewer miles of sewer pipes and pump stations and services slightly more properties (see Table 3-1), which is primarily due to greater use of gravity sewers as compared to the large number of low-pressure sewers proposed in the 2010 CWMP.

Figure 3-1. Updated Service Areas and Phasing



Orleans installed new water meters Town-wide and started collecting flow information in FY2022. These meters more accurately capture water use and, therefore, allow for a more accurate projection of sewage flows. **Table 3-4** below shows the total water use data for each service area and the flow for areas outside of the core service area for the fiscal years 2022 (i.e., July 1, 2021, to June 30, 2022) and 2023 (i.e., July 1, 2022, to June 30, 2023). The new current water use data is more accurate than the water use data that was used as the basis for the Massachusetts Estuaries Project report (Howes et al., 2006). The water use in Town was fairly consistent, with a difference between FY2022 and FY2023 of only 4% Town-wide. For nitrogen removal estimation purposes and planning for WWTF expansion, the average water use for these two years was used, and going forward a rolling three-year average will be used.

Table 3-4. Water Data Summary by Classification Area 2022-2023

Water Data Summary by Classification Area			
Area	**FY22 (gpd)**	**FY23 (gpd)**	**% Difference FY22 to FY23 by Area**
Downtown	118,614	122,999	4%
Downtown - 2	5,216	6,172	15%
Meetinghouse Pond	59,112	61,571	4%
Meetinghouse Pond - 2	4,739	5,450	13%
Meetinghouse Pond - North	26,278	28,327	7%
South Orleans - A	15,261	16,532	8%
South Orleans - E	21,942	22,263	1%
South Orleans - B	17,848	17,645	-1%
South Orleans - F	16,534	18,318	10%
South Orleans - C	11,674	12,486	7%
South Orleans - D	5,942	5,807	-2%
Pochet West	30,231	29,033	-4%
Pochet East	16,582	16,893	2%
Tonset 1	10,911	11,781	7%
Tonset 2	36,816	39,154	6%
Eldredge Parkway 1	8,120	7,789	-4%
Eldredge Parkway 2	19,431	19,868	2%
Rock Harbor	13,308	15,319	13%
Lakes and Ponds	39,726	44,909	12%
Lakes and Ponds - Alternate	4,797	4,862	1%
Outside Core Area	326,478	336,911	6%
TOTAL TOWNWIDE	**809,559**	**844,089**	**4%**

A planning level estimate of 4 kg/yr/parcel nitrogen removed was used to assess projected nitrogen removals for each planned sewer service area, based on calculations prepared by Wright-Pierce (Wright-Pierce, 2023a). Wright-Pierce's current estimate is based on the 2022-2023 water consumption and attenuation (3.75 kg/yr/parcel). Water use data was used to calculate nitrogen loadings by sorting data into 27 sub-watersheds, serving 3,697 properties. Each sub-watershed was grouped into three categories (no upgradient loads, upgradient loads, and tributary to freshwater pond with natural attenuation). Once grouped, ponds were linked to the downgradient sub-watersheds and a 50% attenuation factor to the upgradient load was applied. The nitrogen load removals from sub-embayments and downgradient ponds were combined with the attenuated load removals from upgradient ponds. This resulted in a planning level estimate of predicted nitrogen removal. It is assumed that 100% of the sewer nitrogen loading is removed in areas that are sewered. Using this same methodology, the nitrogen removal number had

been estimated at approximately 4.5 kg/yr/parcel N removal before the updated water use data was available. In comparison, the 2006 MEP Report for Pleasant Bay estimated septic nitrogen loading as 4.8 kg/year/residential parcel.

The projected nitrogen removal that can be accomplished by installing sewers in the planned sixteen service areas was estimated using both the 4 and 4.5 kg/yr/parcel N removal and compared to the nitrogen removal goals currently identified in the Pleasant Bay TMDL report and the MEP reports for other watersheds. **Table 3-5** and **Table 3-6** include for each of the sixteen service areas the anticipated nitrogen removal and TMDL/MEP nitrogen removal goals by watershed. The difference between these tables highlights one of the variables (N removal rate) that impact planning for infrastructure improvements. **Tables 3-5** and **3-6** depict wastewater flows at the current level of development based on water records. These flows reflect a number of assumptions that will be modified and addressed through adaptive management as the program is implemented.

Table 3-5. 4 kg/yr Nitrogen Removal per Developed Parcel

Phase	Project	Timeframe (year)	Wastewater Flow		WWTF Expansion Phasing	Nitrogen (N) Removal Based on Current Development					
			Est. Flow to WWTF, Incl. I/I (gpd ADF)*	Cumulative Flow to WWTF, Incl. I/I (gpd ADF)		N Removal per Service Area (kg/yr)	Cumulative N Removal (kg/yr)	N Removal Per Watershed			
								Nauset Harbor	Rock Harbor	Pleasant Bay	Little Namskaket
1	Downtown 1	Complete	129,709	129,709	Current WWTF	4,588	4,588	1,584	2,092	-	912
2	Meetinghouse Pond (1&2)	- 2026	81,966	211,675		1,872	6,460	156	-	1,716	-
3	Lakes and Ponds (Incl. Arey's Pond)	2024 - 2028	53,870	265,545		1,248	7,708	32	-	1,216	-
4	South Orleans - A	2027 - 2031	23,406	288,951		572	8,280	-	-	572	-
5	South Orleans - E	2030 - 2034	28,252	317,203	Upgrade Planning/Design	548	8,828	-	-	548	-
6	South Orleans - B	2033 - 2037	22,700	339,903	WWTF Upgrade Construction	440	9,268	-	-	440	-
7	South Orleans - F	2036 - 2040	21,665	361,568		320	9,588	-	-	320	-
8	South Orleans - C & D	2039 - 2043	23,627	385,195	Upgraded WWTF Online	432	10,020	-	-	432	-
9	Pochet West	2042 - 2046	36,922	422,117		724	10,744	-	-	724	-
10	Pochet East	2045 - 2049	21,000	443,117		396	11,140	-	-	396	-
11	Mill Pond / Pochet North	2048 - 2052	35,154	478,271		796	11,936	588	-	208	-
12	Town Cove South	2051 - 2055	14,314	492,585		344	12,280	344	-	-	-
13	Tonset	2054 - 2058	45,439	538,025		1,008	13,288	1,008	-	-	-
14	Eldredge Park Way 1 & Little Namskaket	2057 - 2061	18,738	556,762		444	13,732	84	356	-	4
15	Eldredge Park Way 2	2060 - 2064	26,857	583,619		876	14,608	640	4	232	-
16	Rock Harbor	2063 - 2067	18,161	601,780		472	15,080	-	472	-	-

Estimated N Removal (kg/yr/watershed)	**4,436**	**2,924**	**6,804**	**916**
MEP Removal Goal	5,000	1,500	6,980	-
Difference	564	(1,424)	176	(916)

Current WWTF Max Capacity = 350,000 gpd ADF

Design for new WWTP at ~80% capacity

**No TMDLs for Rock Harbor, Nauset Harbor, or Little Namskaket

Table 3-6. 4.5 kg Nitrogen Removal

Phase	Project	Timeframe (year)	Wastewater Flow		WWTF Expansion Phasing	Nitrogen (N) Removal Based on Current Development					
			Est. Flow to WWTF, Incl. I/I (gpd ADF)*	Cumulative Flow to WWTF, Incl. I/I (gpd ADF)		N Removal per Service Area (kg/yr)	Cumulative N Removal (kg/yr)	N Removal Per Watershed			
								Nauset Harbor	Rock Harbor	Pleasant Bay	Little Namskaket
1	Downtown 1	Complete	129,709	129,709	Current WWTF	5,162	5,162	1,782	2,354	-	1,026
2	Meetinghouse Pond (1&2)	- 2025	81,966	211,675		2,106	7,268	176	-	1,931	-
3	Lakes and Ponds (Incl. Arey's Pond)	2024 - 2028	53,870	265,545		1,404	8,672	36	-	1,368	-
4	South Orleans - A	2027 - 2031	23,406	288,951		644	9,315	-	-	644	-
5	South Orleans - E	2030 - 2034	28,252	317,203	Upgrade Planning/Design	617	9,932	-	-	617	-
6	South Orleans - B	2033 - 2037	22,700	339,903	WWTF Upgrade	495	10,427	-	-	495	-
7	South Orleans - F	2036 - 2040	21,665	361,568	Construction	360	10,787	-	-	360	-
8	South Orleans - C & D	2039 - 2043	23,627	385,195	Upgraded WWTF Online	486	11,273	-	-	486	-
9	Pochet West	2042 - 2046	36,922	422,117		815	12,087	-	-	815	-
10	Pochet East	2045 - 2049	21,000	443,117		446	12,533	-	-	446	-
11	Mill Pond / Pochet North	2048 - 2052	35,154	478,271		896	13,428	662	-	234	-
12	Town Cove South	2051 - 2055	14,314	492,585		387	13,815	387	-	-	-
13	Tonset	2054 - 2058	45,439	538,025		1,134	14,949	1,134	-	-	-
14	Eldredge Park Way 1 & Little Namskaket	2057 - 2061	18,738	556,762		500	15,449	95	401	-	5
15	Eldredge Park Way 2	2060 - 2064	26,857	583,619		986	16,434	720	5	261	-
16	Rock Harbor	2063 - 2067	18,161	601,780		531	16,965	-	531	-	-
							Estimated N Removal (kg/yr/ watershed)	4,991	3,290	7,655	1,031
							Removal Goal	5,000	1,500	6,980	-
							Difference	10	(1,790)	(675)	(1,031)

Current WWTF Max Capacity = 350,000 gpd ADF

Design for new WWTP at ~80% capacity

*Est. Flow is based on average FY22 and FY 23 water use data

**No TMDLs for Rock Harbor, Nauset Harbor, or Little Namskaket

As discussed with MassDEP at a September 28, 2023, pre-filing meeting (**Attachment E**), the modeling included in the 2012 MEP report for Nauset Harbor (Howes et al., 2012) in particular requires further study and additional modeling, which is not yet scheduled. In addition, the 2006 Pleasant Bay TMDL report (Howes et. al., 2006) and nitrogen removal goals included therein were based on conditions which have since changed due to the breach in the barrier island system that separates Pleasant Bay from the Atlantic Ocean. Therefore, the nitrogen removal goals shown in **Table 3-5** and **Table 3-6** are planning level goals subject to change in the future. As seen in **Table 3-5** and **Table 3-6**, the proposed sewering either meets the nitrogen removal goals or comes very close to the goals, depending on the flows and nitrogen removal assumed and the receiving watershed. As discussed below in Sections 4 and 5, NT Technologies and an Adaptive Management approach will allow flexibility to revise implementation of the Wastewater Management Plan as goals and variables impacting nutrient loading are refined.

3.3 Phase 1 - New WWTF

Dedicated individual treatment facilities for the Downtown Area and Meetinghouse Pond Area sewer service areas were considered in early stages of planning. Based on a technical evaluation and cost analysis, however, it was determined that one combined treatment facility was more economical and provided numerous operational advantages.

A new WWTF was constructed on Overland Way between 2022 and 2023 at the general location of the old Tri-Town Septage Treatment Facility. The WWTF was sited to reduce the impact on NHESP Priority Habitat. The exterior architectural design of the WWTF is intended to convey a state-of-the-art treatment facility using attractive and highly durable materials that require minimal maintenance. All exterior and interior materials were selected for durability and maintainability.

The required capacity of the WWTF was developed based on water use records for developed parcels with some allowance for inflow and infiltration as well as growth. The WWTF has been designed such that a “mirror image” of the current plant could be constructed to accommodate an additional 350,000 gpd for a total of 700,000 gpd. **Table 3-5** shows that the Town should anticipate starting planning for the new facility in the early 2030s with the new expanded facility coming online in the late 2030s or early 2040s.

3.4 Phase 2 - Meetinghouse Pond

Phase 2 consists of the construction of a combination of gravity sewers and low-pressure sewers (LPS) to service the Meetinghouse Pond Area. Wastewater flows from the Meetinghouse Pond Area to the Phase 1 Downtown Area Collection System. Flow is treated at the WWTF and disposed of at the effluent disposal site on Lots Hollow Road. The Phase 2 Area services 458 properties of which approximately 90% are residential and 10% are non-residential/mixed-use properties. The Meetinghouse Pond Area Collection System and Pumping Station Project includes approximately 15,750 linear feet of 8-inch through 18-inch PVC GS and appurtenances, approximately 7,500 linear feet of 8-inch PVC force main and appurtenances, approximately 20,750 linear feet of 1.5-inch through 3-inch LPS and appurtenances, and one Submersible Pumping Station and appurtenances. As noted in **Table 3-4** above, Meetinghouse Pond sewering is estimated to remove approximately 2,106 kg N/yr based on a nitrogen removal rate of 4 kg N/parcel; of this amount, approximately 156 kg/N is estimated to be removed from Nauset Harbor, and approximately 1,716 is estimated to be removed from the Pleasant Bay watershed.

The Town voted at the Fall 2023 Town Meeting to approve expansion of Phase 2 to include the Meetinghouse Pond 2 service area as an additional step towards meeting the Town’s requirements for nitrogen removal from the Pleasant Bay Watershed. Assuming a favorable quote and determination of State Revolving Fund (SRF) financing for this modification to the existing Phase 2 construction contract, Phase 2 will include sewers for 41 properties in the Meetinghouse Pond 2 service area.

3.5 Future Wastewater Collection Phases

A Collection System Technologies and Evaluation Technical Memorandum (AECOM, 2016a) was prepared to identify types of collection system technologies and to evaluate those technologies. The technologies for the next future sewer phases are consistent with those used in Phases 1 and 2 and include gravity and low-pressure sewers. **Table 3-7.7** below shows the type and length of sewer lines and the location of the pump stations for each specific sewer phase. Figure 3-1. Updated Service Areas and Phasing illustrates the proposed sewer phase locations. It is important to remember that alignments and facility locations have not undergone detailed engineering and environmental evaluation and are subject to change. They are provided for planning purposes and as an exercise to highlight potential impacts.

Table 3-7.7 Updated Sewer Phases

Phase	Name	Pump Stations	Gravity Sewer	Low Pressure	Force Main	Approximate Sewer Length (miles)
3	Lakes and Ponds	Finlay Rd	X	X	X	7.5
4	South Orleans - A	Harwich Rd.	X	X	X	3.8
5	South Orleans - E	Lake Dr.	X	X	X	3.4
6	South Orleans - B	Namequoit Rd.	X	X	X	3.4
7	South Orleans – F	Towhee Ln.	X	X	X	2.5
8	South Orleans – C & D	Indian Fort Hill (C) Aunt Abigail's Way (D)	X	X	X	3.7
9	Pochet West	Fox Ridge Dr	X	X	X	4.2
10	Pochet East		X	X		1.8
11	Mill Pond/Pochet North	Great Oak Rd.	X	X	X	3.7
12	Town Cove South		X	X		1.4
13	Tonset		X	X		4.0
14	Eldredge Parkway 1 & Little Namskaket		X	X (Little Namskaket)		2.5
15	Eldredge Parkway 2		X		X	3.1
16	Rock Harbor	Rock Harbor Rd.	X	X	X	2.5
					Total	47.5

3.6 Environmental Impact

The construction for the new sewer lines is anticipated to take place in roads or upland areas. Some sewer lines may be installed through Areas of Critical Environmental Concern (ACEC), Priority Habitats of Rare Species, and Estimated Habitats of Rare Species, but within existing roads. Pump stations are anticipated to be installed off streets, and a few are located in Bordering Land Subject to Flooding (BLSF) or Land Subject to Coastal Storm Flowage (LSCSF). Based on the need to locate pump stations at low points, it may be challenging to locate some pump stations outside of BLSF and LSCSF, however the exact siting will be further evaluated during design of each sewer phase. If pump stations are located in BLSF or LSCSF, floodproofing measures will be implemented in consideration of future climate change precipitation and storm surge conditions, and Notices of Intent will be filed with the Orleans Conservation

Commission in accordance with the requirements of the Massachusetts Wetlands Protection Act (WPA) regulations. Some pump stations may also require siting within ACEC habitat or NHESP Estimated or Priority Habitat, which was also required as part of the original 2010 CWMP approved by MEPA. If detailed design confirms that a pump station must be located within NHESP Estimated or Priority Habitat, the Town will consult with NHESP regarding the need for review under the Massachusetts Endangered Species Act.

3.7 Municipal Area Beyond Core Service Area

No sewering is proposed outside of the "Core Area" at this time. As described above in Section 3.2, it is anticipated that nitrogen removal needs for the watersheds within Orleans can either be met or almost met, based on sewering the "Core Area". PRBs (Section 4.3) in Pleasant Bay and Nauset Harbor outside of the "Core Area" are being considered. If future needs are not met through the traditional means of nitrogen removal, PRBs will help to further reduce nitrogen loading. In addition to PRBs, nitrogen reduction may be achieved through aquaculture (as discussed below in Section 4.2), and other adaptive management approaches, or through naturally occurring nitrogen attenuation.

3.8 Tri-Town Transition

The Orleans-Brewster-Eastham Groundwater Protection District (Tri-Town District) owned and operated the Tri-Town Septage Treatment Facility (TTSTF), located on Overland Way in Orleans, MA. The Facility was constructed over 30 years ago and was designed to treat up to 45,000 gpd of septage and grease. The TTSTF reached the end of its useful life and Stantec Consulting Services Inc. was hired by the Tri-Town District to prepare a decommissioning plan ("Tri-Town Septage Treatment Facility Decommissioning Action Plan", October 18, 2013). The Plan provided a path to decommission and demolish the 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 GWDP were both extended until December 2016.

On January 21, 2016, the Tri-Town District voted to not fund interim improvements estimated at approximately $1,000,000 to extend the facility for an additional five years. The facility ceased the receipt of septage on June 1, 2016, and ceased operations on October 31, 2016. Demolition began in 2017 and was completed in May 2020. The new WWTF has been designed to accept septage from local haulers, though at a reduced rate of 16,000 gpd. This value was determined based on a market analysis and balancing the municipal sewer needs against septic traffic.

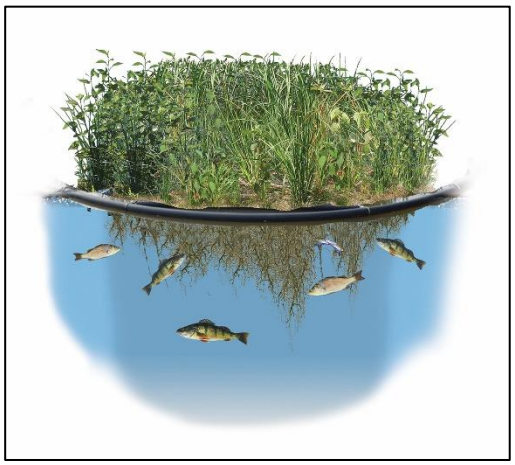
4. Non-Traditional Technologies

As recognized in the 2010 CWMP/SEIR and the Consensus Agreement, Non-Traditional (NT) nitrogen control strategies can reduce the volume of wastewater that requires nitrogen removal treatment at wastewater treatment facilities resulting in potential lower management costs for the Town. This section provides an overview of the types of NT Technologies considered as part of the Hybrid Approach to wastewater management in Orleans. It also discusses the completed and ongoing demonstration projects implemented to test and confirm the effectiveness of specific technologies in select locations of the Town. The 2015 Consensus Agreement recommended three 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, aquaculture/shellfish propagation, and permeable reactive barriers. An additional innovative NT Technology, a nitrogen reducing biofilter, was also considered for implementation in Orleans. This section describes each of these NT Technology tools, discusses the site selection process for demonstration projects for each NT Technology, describes the work plan associated with the demonstration projects, and discusses full-scale implementation of aquaculture and PRBs.

4.1 Floating Constructed Wetlands

Floating constructed wetlands (**Figure 4-1**) are one of the NT Technologies that have been considered to reduce nitrogen loads to receiving waters. The "Final Site Characterization and Evaluation Technical Memorandum" (AECOM, 2016b; **Attachment G**) documents the process used to identify, evaluate, rate, rank, and ultimately recommend specific demonstration sites to test the efficacy of FCWs for nitrogen removal. The Work Plan Technical Memorandum (AECOM, 2016c; **Attachment H**) sets forth the conceptual design of the FCW, including the project components, sequencing of subtasks, the equipment, labor, and other resources required to construct the FCW. It also includes a preliminary cost estimate. Ultimately the Town decided to curtail pursuit of FCW implementation after review of the costs for implementing FCWs, operations and maintenance considerations, and lack of effective locations, as well as the uncertainty of the nitrogen removal that could be achieved.

Figure 4-1. Illustration of a Floating Constructed Wetland



4.2 Aquaculture

Aquaculture is a NT Technology the Town has incorporated into its water quality management approach. Previously four demonstration projects were evaluated to obtain site-specific information within Orleans waterbodies and then determined the viability of full-scale implementation. The locations evaluated included Town Cove, Kent's Point, Pleasant Bay, and Lonnie's Pond. Only the Lonnie's Pond demonstration project was fully implemented. The other sites were determined to be not cost-effective. The Town does not plan to expand the program to locations other than Lonnie's Pond at this time.

4.2.1 Aquaculture Success at Lonnie's Pond

The "Final Site Characterization and Evaluation Technical Memorandum" (AECOM 2016d; **Attachment I)** presents the process used to identify, evaluate, rank, and recommend specific shellfish demonstration sites. The Memorandum includes:

- A description of the initial process that was employed to develop the Orleans Consensus Agreement and associated potential demonstration sites;

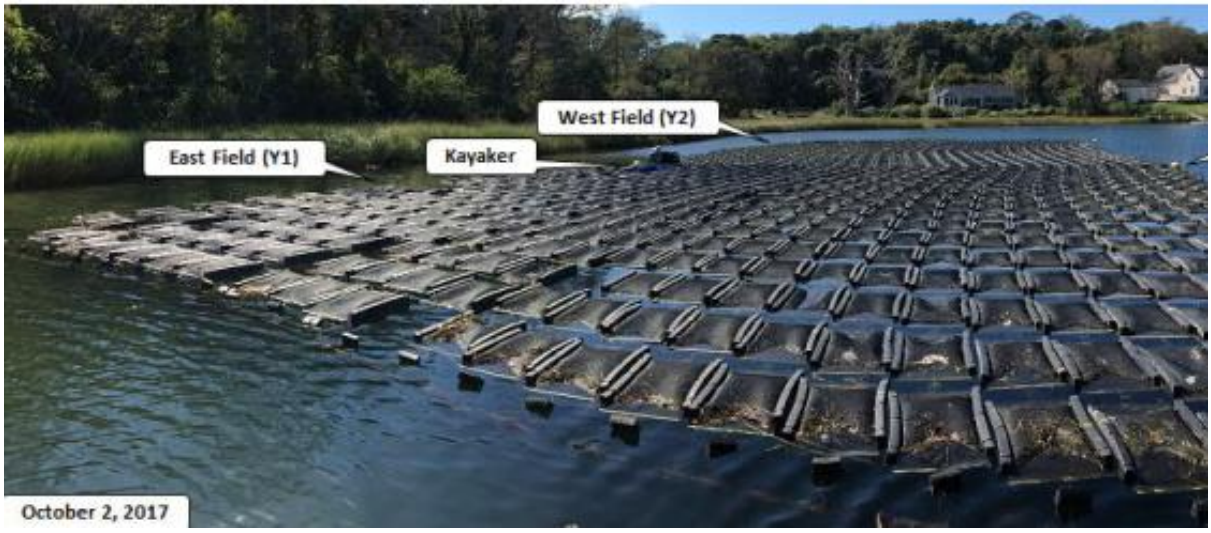
- Next steps that were taken in the process of evaluating demonstration sites;
- Data that was available to help evaluate potential demonstration sites;
- Evaluation and ranking of sites based on the site selection matrix and criteria; and
- Recommended demonstration sites paired with specific shellfish propagation approaches (such as bottom planting hard shell clams, oyster beds or oyster aquaculture), and rationale for selection.

Kescayo-Gansett (Lonnie's) Pond was identified as the preferred location for the Town's first aquaculture demonstration project based on several factors. Factors included the Town's strong desire to improve the environmental conditions in their terminal ponds (many of which include anoxic, muddy sediments) and the expected ability to monitor water quality and other impacts caused by shellfish in this semi-closed sub-embayment. In addition, Lonnie's Pond was selected due to its favorable growing conditions and site-specific characteristics which facilitate monitoring water quality and sediments denitrification. In 2016, the Town of Orleans established the Lonnie's Pond aquaculture demonstration project to evaluate the amount of nitrogen removed from the water column by oysters grown in a terminal, coastal pond for three years (2016 - 2018). The uptake was assessed under various oyster stocking density scenarios to determine the logistics of implementing long-term oyster aquaculture. Nitrogen removal was evaluated by monitoring change in nitrogen content in oysters from the beginning to end of the growing season each year. Direct nitrogen uptake by the oyster biomass was well documented during the three-year demonstration project, and the results were consistent with nitrogen removal rates documented in other studies.

Following the success of the demonstration project, the Town of Orleans worked with SMAST to develop the Lonnie's Pond Aquaculture and Nitrogen Management Plan (AECOM 2018b, **Attachment J**). The purpose of the Plan was to facilitate the transition from an oyster aquaculture demonstration project to a sustainable long-term oyster aquaculture system for nitrogen removal and move toward achieving compliance with the TMDL (Orleans, 2018). On March 15, 2019, AECOM submitted a Notice of Project Change on behalf of the Town of Orleans to the MEPA Office in accordance with 301 CMR 11.10(1). MEPA approval was received on April 19, 2019. The 2019 NPC provided monitoring results for the demonstration project in Lonnie's Pond. Data indicated that nitrogen content in Year 1 and Year 2 oysters was 10.5% and 10.3% respectively. They removed 25.9 kg of Nitrogen in 2016 and 28.1 in 2017, showing favorable results. Aquaculture activities that took place in Lonnie's Pond were conducted by the Town under the authority of a Municipal Propagation Permit. At the time of the 2019 NPC, no decisions were made for full-scale implementations. Also included in the 2019 NPC were measures taken to minimize and avoid environmental impacts associated with the Lonnie's Pond Aquaculture project. It was concluded that no further MEPA review of the 2019 NPC was required. The 2019 NPC Certificate is included as **Attachment A** and comments received from state agencies on the 2019 NPC can be viewed in **Attachment D**.

The Town elected to contract with a third party to continue this demonstration project beyond 2019. Ward Aquafarms was awarded the contract to Lonnie's Pond aquaculture operation in 2019 and continues to farm through present day. Ward Aquafarms is responsible for purchasing, transporting, installing, maintaining, and removing the shellfish. Aquaculture activities are performed in accordance with the Coastal Systems Program at SMAST.

Figure 4-2. Oyster Deployment



SMAST was selected to perform nitrogen monitoring. The oysters are weighed at the beginning and end of the deployment period. SMAST has been conducting nitrogen analyses of the shell and tissue of the oysters as well as water quality monitoring. The two contractors are required to coordinate with each other, and Ward Aquafarms is required to provide access to the required number of oysters at the agreed upon dates of the project season. **Figure 4-2** displays the Oyster bag location and set up in Lonnie's Pond.

During both the demonstration project and current long-term aquaculture operation, the SMAST Quality Assurance Policy Plan for water quality and benthic denitrification and infauna sampling has been followed. As a part of this, SMAST compiles annual nitrogen removal and water quality reports. In addition to annual nitrogen removal, SMAST quantifies water quality changes that occur from year to year, with twice monthly sampling from March to October. The following parameters are measured at both water surface and bottom locations (where depth is greater than five 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;
- Phosphate (PO_4), (Soluble Reactive Phosphate (SRP));
- Salinity;
- Dissolved oxygen (DO); and
- Transparency (Secchi depth). (SMAST, 2019)

In 2022, 12 sampling visits occurred between April 6th and October 18th. In addition to biweekly samples, continuous monitoring of chlorophyll-a, DO, salinity, temperature, and Secchi depth was conducted at two sites directly east and west of the southernmost oyster deployment area. In 2023, continuous monitoring

devices were installed approximately 30 cm off the bottom. Nine monitoring stations were established to determine water quality changes due to the oyster aquaculture:

- 1 Sentinel (Middle of Pond);
- 1 Northern;
- 1 at the Coast to the South (Western);
- 1 in Tidal River Channel; and
- 5 Around the Oyster Deployment Area.

SMAST samples each location every other week and Town volunteers collect surface water inflows and Secchi depth readings at the Sentinel Station every other week. A report at the conclusion of the monitoring program each year is prepared by SMAST and submitted to the Town at the beginning of the following year.

The 2022 Lonnie's Pond Annual Report determined that in recent years there has been a significant shift in the benthic community from oligochaetes (various types of earthworms) to amphipods (various types of crustaceans). This is indicative of a healthier ecosystem with lessening impairment and is a sign of the progress stimulated from nitrogen removal by aquaculture.

Nitrogen removal from an aquaculture deployment of approximately 0.37 acre has ranged between approximately 51 and 84 kg N/year since 2018, resulting in an average removal of approximately 64 kilograms of nitrogen each year (kg N/yr) over this time period. In the last three years of implantation by Ward Aquafarms, aquaculture has removed an average of approximately 67 kg N/yr. Year-to-year results indicate that early season and longer deployment of year two oysters results in the greatest N removal. Additionally, the 2022 report determined that reducing oyster mortality and culling oysters prior to deployment is another key for nitrogen removal.

Lonnie's Pond was selected for the demonstration project and long-term implementation due to its unique characteristics, including relatively low boat traffic, shelter from storms, favorable oyster growing features, bottom conditions, and favorable geometry for water quality sampling and evaluation. Due to siting constraints, Orleans does not intend to propose additional aquaculture sites as part of its approach to reduce nitrogen loading.

4.2.2 Aquaculture Nitrogen Credit

The Town of Orleans has conducted ground-breaking analysis of aquaculture and evaluated the effectiveness of a Non-Traditional Technology that has the potential for significant nitrogen removal. The Town of Orleans has conducted extensive work with oyster aquaculture through the evaluation of potential sites, implementation of demonstration projects, and long-term aquaculture management. This work completed by the Town will contribute to the use of aquaculture for nitrogen removal becoming a standard practice for other municipalities. Aquaculture practices are cost-effective and community-based that serve as effective complements to other traditional approaches to nitrogen removal.

Following the three-year demonstration project, the Town of Orleans decided to continue with the use of aquaculture as a method of reaching TMDL compliance in the Lonnie's Pond watershed. This decision was based on the understanding that MassDEP would provide a nitrogen removal credit for aquaculture. In June 2022, Orleans submitted a letter requesting credit for the Town's aquaculture program at Lonnie's Pond and is expecting MassDEP approval of a credit for this NT Technology. In a September 2023 meeting, MassDEP indicated that a response to the 2022 nitrogen credit request is forthcoming (**Attachment E**).

There are two main mechanisms of oyster aquaculture that remove nitrogen from the water column. One is the direct uptake from oyster growth, which is found in the oyster's biomass (their shells and tissues).

The other is nitrogen removal through denitrification. This process occurs through the growing season from enhanced biochemical processes in the sediment caused by oyster biodeposits. Since direct uptake of nitrogen is more easily quantifiable, only this portion of nitrogen removal is currently being sought for a nitrogen removal credit from MassDEP. However, analysis of enhanced sediment denitrification that can be attributed to oyster aquaculture is still critical to determining the impact of oysters on the estuary in which they are grown. The current monitoring is extensive and expensive. The Town's work has established the feasibility of using aquaculture for nitrogen removal, and as this becomes a standard and recognized MassDEP approach for nitrogen removal, it is expected that MassDEP will accept a more stream-lined monitoring protocol.

Lonnie's Pond aquaculture was included in the Pleasant Bay Watershed Management Plan as a component of the Town of Orleans' approach to meeting its share of the Pleasant Bay nitrogen removal goals. Table 1 of the Pleasant Bay Watershed Implementation Plan from May 2018 indicated that Lonnie's Pond Aquaculture would account for 273 kg of nitrogen removed from 2019 to 2023. Although this goal was not attained aquaculture is still considered a successful nitrogen removal method. The Pleasant Bay Association (PBA) 2023 five-year review report states that PBA has accepted the Lonnie's Pond aquaculture nitrogen removal performance at 67 kg/yr. The current 67kg/yr nitrogen removal is 23% of the removal need for Lonnie's Pond and 1% of overall removal need for Orleans Pleasant Bay watershed, before consideration of growth in watershed loads.

4.2.3 Aquaculture Environmental Impact

The environmental impacts of the Lonnie's Pond aquaculture were described in the 2019 NPC, which was approved by MEPA without the need for an EIR. The deployment area of this project occupies 0.37 acres (2% of the pond area) and entails six square feet of impact to Land Under Water (LUW). Impacts to the substrate (fill) of Lonnie's Pond has been minimized by the use of narrow diameter telescoping pole anchors that occupy much less are of the substrate than blocks. Work to address abutters concerns as much as possible, including visual impacts, minimizing noise, restricting work hours, and minimizing vehicle parking at the boat ramp has been and will continue to be a priority.

4.3 Permeable Reactive Barriers

Permeable reactive barriers are a third Non-Traditional Technology considered by the Town of Orleans for nitrogen load reduction. The Technical Memorandum "Site Characterization and Evaluation for Permeable Reactive Barriers (Evaluation Criteria and Ranking)" (AECOM 2016e; **Attachment K**) describes in detail the process involved in identifying, evaluating, and selecting potential sites for PRB demonstrations. The selected locations were then used to develop a "Preliminary Engineering Work Plan Technical Memorandum" (AECOM 2016f; **Attachment L**), which detailed designs, schedules, and costs for PRB demonstrations. Strategies for performance verification through groundwater monitoring are included in the Work Plan as well.

Nitrogen loading from point and non-point sources in the watersheds impacts 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, the dominant species of nitrogen found in Orleans' groundwater, in their respiration. This process of bacterial metabolism results in the conversion of nitrate to inert nitrogen gas (denitrification) and requires both anoxic conditions and sufficient food substrate for bacterial growth. PRBs provide the food substrate to deplete oxygen levels, resulting in conditions that favor the denitrifying bacteria and promote their growth. The PRB treatment zone is located in groundwater below the water table. Nitrate is removed in the ground (in-situ) as groundwater flows through the permeable barrier. PRBs also address stormwater and fertilizer loads from upgradient properties.

The PRB is constructed by injecting emulsified vegetable oil into a plume of nitrogen-rich groundwater (**Figure 4-3**). The oil is injected by a relatively small set of equipment in a line of injection points that is perpendicular to the groundwater flow. Monitoring wells are established on the up- and down-gradient side of the curtain of oil to measure groundwater gradient, nitrogen concentrations, and a series of other water quality parameters.

Figure 4-3. PRB Injections



4.3.1 Demonstration Project Site Selection

The specific methodology used for detailed site evaluations included reviewing potential PRB locations developed through the Consensus Agreement process. The review was expanded to include additional locations within the Town that may not have been previously identified. Potential PRBs were assessed with the online Multi-Variant Planning Tool known as Watershed MVP, developed by the CCC. Site evaluations also included field visits and review of existing soil and groundwater quality data. Potential demonstration sites were discussed with Town Officials and ranked based on criteria using a Site Selection Matrix. Selected site locations were targeted for additional field investigation and Work Plan cost estimates.

Eight potential locations for PRB demonstrations were considered in detail:

- Main Street and Tonset Road (Main Street);
- South Orleans Road at Tonset/Eldredge Park Way (Route 28);
- Town Cove Gibson Road;
- Namequoit Road;
- Town Landfill;
- Paw Wah Pond;
- Rock Harbor Road Area; and
- Kescayo-Gansett Pond (Lonnie's Pond).

A refined Site Selection Matrix was developed for a site suitability evaluation of the selected PRB sites. The Matrix included criteria for site suitability, permitting, project evaluation, and other overriding considerations. These criteria addressed the environmental, land use, and implementation features of the proposed demonstration locations. Permitting criteria assessed regulatory requirements and potential conflicts related to the proposed demonstration locations. Project evaluation criteria evaluated the benefits gained from a proposed demonstration site. Other overriding considerations referred to other superseding issues that support or prevent a demonstration at a given site. A ranking system was then developed to quantify how well each site met a specific criterion. Results of the evaluation ranking are presented in Table 2 of the Technical Memorandum (**Attachment K**). The site suitability evaluation process further narrowed the list of potential Demonstration Test sites to the following four locations:

- Main Street and Tonset Road;
- South Orleans Road at Tonset/Eldredge Park Way;
- Town Cove Gibson Road; and
- Town Landfill.

4.3.2 Demonstration Site Hydrogeological Investigations

To support further evaluation of these four 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. AECOM completed hydrogeological investigations at the above four selected sites in the Town to support the design of the demonstration tests. Demonstration tests and groundwater nitrate treatment 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 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.

Based on the 2016 investigation, the demonstration test site at Eldredge Park was selected. The Eldredge Park site had sufficient groundwater nitrogen data to support a demonstration project. The location is considered 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 Park Way at the Nauset Regional Middle School.

A summary of field and laboratory groundwater data is presented in Table 3 and Section 4.b.5 of the Technical Memorandum (**Attachment L**).

4.3.3 Demonstration Project Testing

A demonstration project was started in November 2016 at the Eldredge Park location and is currently ongoing. The location of the demonstration test as well as a layout of injection points is shown on **Figure 4-4**. This site is monitored to assess the effectiveness and applicability of PRBs as a treatment alternative for the Town. The demonstration test is being evaluated against the following performance objectives:

- Achieve satisfactory distribution of the carbon substrate solution into the subsurface;
- Establish and maintain necessary anaerobic (reducing) and groundwater flow conditions in the subsurface throughout the targeted treatment area;
- Demonstrate reduced nitrate concentrations and flux in groundwater through monitoring to extrapolate to reduction targets for full scale project;
- Demonstrate performance, compliance monitoring, and assessment of treated water quality, including potential secondary water quality affects, through a groundwater monitoring program;
- Evaluate the time frame for technology performance;
- Evaluate potential impacts to sensitive receptors (surface water, private wells, etc.); and
- Obtain data for engineering evaluations and to optimize full-scale design and implementation.

Full-scale PRBs are anticipated to be 500 to 3,000 feet long, depending on the location. Demonstration test PRBs are shorter to more easily assess construction/implementation, and to allow adequate monitoring of groundwater conditions in the vicinity of the PRBs. For the demonstration test PRBs, a vertical treatment interval is installed from the top of the groundwater table to approximately 30 to 40 feet into the saturated soils. The exact dimensions and other characteristics of the PRB are determined via

additional groundwater assessment. Multi-level groundwater sampling events conducted on Cape Cod have identified 25- to 40-foot-thick bands of groundwater containing nitrate (MT Environmental, 2015). The initial field groundwater investigation completed by AECOM in 2016 indicated that nitrate is generally present at least 30 feet below the water at concentrations similar to towards the top of the water table. This information supported a vertical groundwater treatment interval of 30 to 40 feet for the demonstration test.

Trench installation was considered and ruled out for PRB demonstrations in Orleans due to limited feasibility, numerous disadvantages, potentially unacceptable environmental impacts, and prohibitive siting requirements. This method requires large construction equipment for installation, limiting possible locations for instillation access, and it is unsuitable to be placed in roadways. Due to the shallow installation depth of 20-feet, trench based PRBs would need to be located very close to surface water in resource areas, causing potential damage to natural resources while increasing permitting requirements and cost as well as the potential for significant abutter concerns. In addition, trench locations may not necessarily provide sufficient downgradient travel time for stabilization of groundwater chemistry before groundwater discharge to the surface water.

4.3.4 Demonstration Project Performance Monitoring

Monitoring began in February 2017 with the most recent monitoring event in October 2022. After the beginning of the monitoring, it was determined that a portion of the area originally targeted for assessment of PRB performance was potentially outside of the area of influence of the PRB due a difference in the groundwater flow direction. The PRB treatment line was extended in 2018 to the north to intercept and treat nitrate in groundwater along this untreated flow path. This modification required additional monitoring well installations to verify flow directions north of the PRB and established an additional PRB injection zone starting at the west end of the current PRB injection zone and extending to the north for approximately 110 feet, roughly along the edge of the athletic field and parking lot areas. The monitoring wells were necessary to verify that the new section of PRB was perpendicular to the direction of groundwater flow. Additional monitoring wells were installed in April 2018 with the PRB extension completed in June 2018 with another round of emulsified vegetable oil (EVO) injections. Monitoring continued through October 2022 and has provided significant insight to PRB effectiveness at reducing nitrogen loading into groundwater. This was based on observed groundwater flow, dissolved organic carbon (DOC) concentrations in groundwater, reductions in nitrate concentration, and changes in redox conditions.

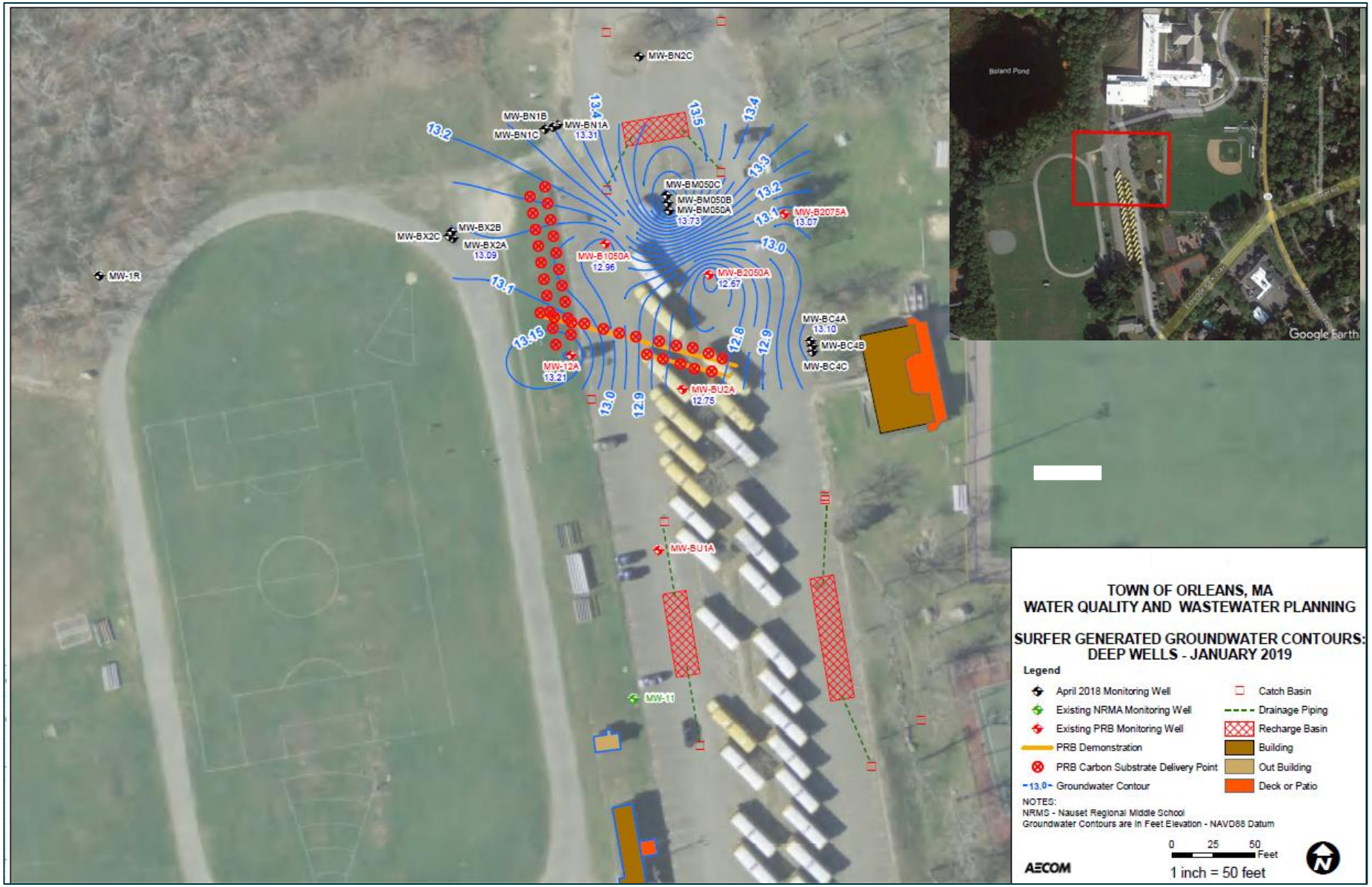
Monitoring of the PRB demonstration project was performed to assess nitrate transformation, concentrations of other key indicators, and the distribution of the injected reagents. Groundwater samples were collected from both existing monitoring wells (previously installed by Nauset Regional Schools) and additional monitoring wells (installed as part of this demonstration project). The monitoring well network for demonstration test performance monitoring is presented in **Figure 4-4** for the Eldredge Park Way PRB. The monitoring well network includes monitoring wells upgradient, downgradient, and cross-gradient of the PRB to evaluate changes to nitrate, groundwater quality, and aquifer permeability as a result of the injection of EVO. These laboratory analyses support evaluation of PRB performance as well as characterize the nitrate plume in groundwater vertically. Groundwater samples were collected prior to initiation of in-situ treatment to provide a comparative baseline to evaluate performance of the demonstration test. Primary objectives of the post-injection sampling were 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;
- Identify extent of generated reducing conditions;
- Evaluate potential for reduction in aquifer permeability as a result of EVO;

- Evaluate persistence of EVO and anaerobic conditions favorable for denitrifying bacteria after PRB installation; and
- Assess changes in groundwater monitoring parameters as a result of the PRB.

Post-injection monitoring data indicates the PRB is functioning as expected, namely by increasing DOC and reducing nitrogen concentrations within the area affected by the PRB. Based on data collected in 2021, Eldredge Parkway Demonstration PRB achieves a greater than 80% nitrogen removal efficiency.

Figure 4-4. Eldredge Park PRB Demonstration Site at Nauset Regional Middle School



4.3.5 PRB Full Scale Implementation

The 2021 “Full-Scale PRB Watershed Planning Memorandum” (**Attachment M**) examined the viability of PRBs in Nauset Estuary, Rock Harbor, and Pleasant Bay locations as shown in **Figure 4-5**

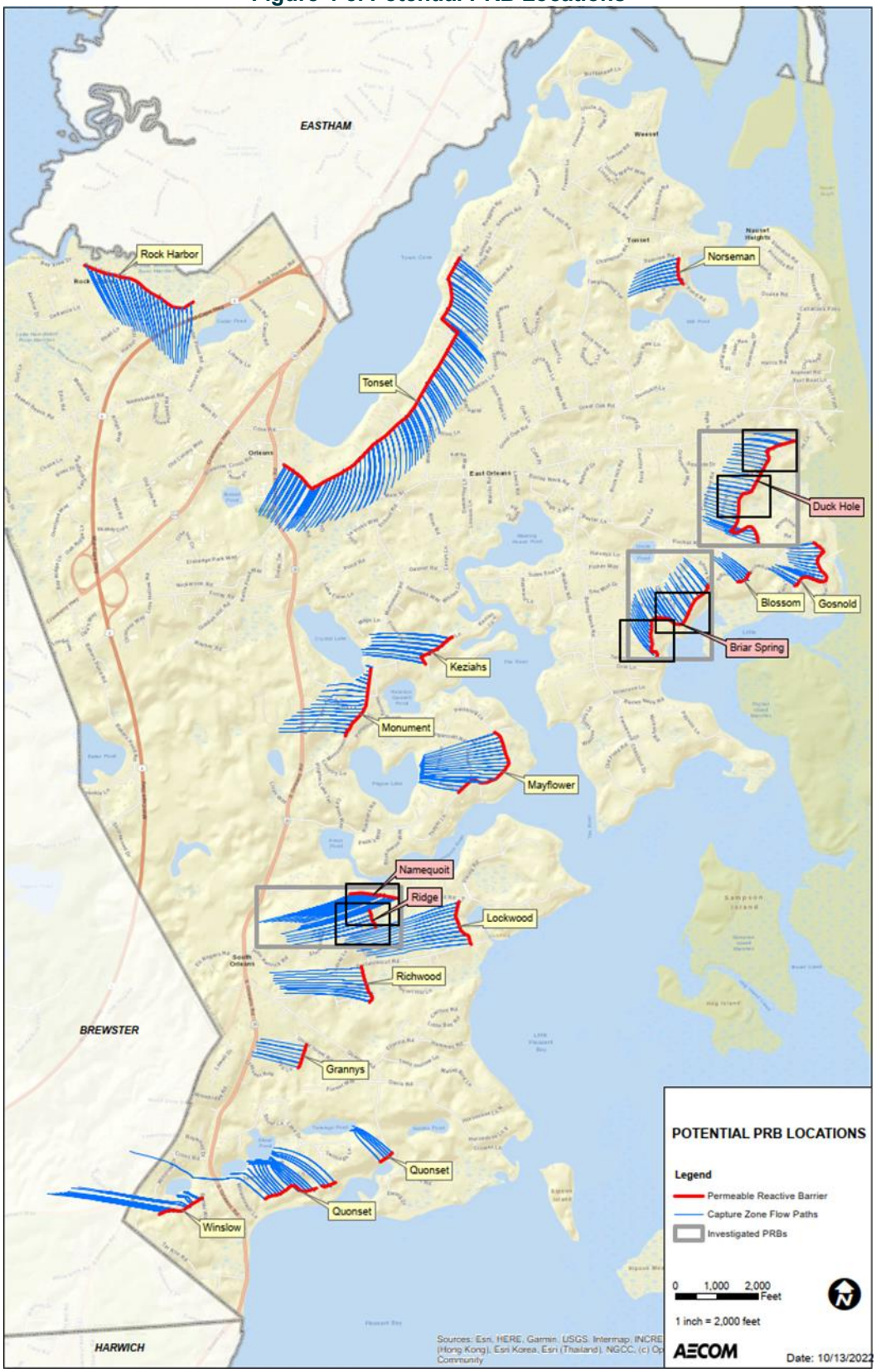
Three potential PRB sites within the Nauset Estuary were identified in the 2021 Memorandum: Tonset, Main Street, and Norseman. AECOM performed a preliminary assessment for nitrogen removal effectiveness at these sites by evaluating the dimensions of the proposed PRBs, groundwater flow direction, upgradient wastewater nitrogen source density, and expected adherence to PRB nitrogen remediation goals. Despite its location in a high-priority upper watershed reach and a high nitrogen loading reduction into Town Cove, Tonset demonstrated low nitrogen removal efficiency, only 0.06 milligram/linear foot/year, because of its greater length (7,300 linear feet) compared to Main Street and Norseman (850 and 580 linear feet, respectively). Site-specific investigations and evaluations were initially recommended for Main Street and Norseman due to their higher efficiencies and significant reduction of nitrogen entering Town Cove. However, the Town has elected not to pursue further investigation of Main Street due to its location close to proposed sewering. Additional geotechnical and hydrogeological evaluation is needed for the Norseman PRB location to confirm the efficacy of a PRB in this location.

One potential PRB site within the Rock Harbor Estuary was identified in the 2021 Memorandum but was not recommended for further examination of PRB installation due to its proximity to a planned traditional wastewater treatment service area and unfavorable life cycle cost compared to the traditional sewer.

Fourteen PRB sites were identified in the Pleasant Bay Watershed in the 2021 Memorandum. Of these sites, the following four potential PRB sites were selected for additional investigation based on high-cost benefit scores combined with their locations along public roads: Duck Hole, Briar Spring, Namequoit Road, and Ridgewood Road. This investigation was intended to inform PRB design and estimate potential nitrogen load reductions in kg/N removed a year. The field investigation at these sites was completed between 2021 and 2022 and the results are summarized in the 2023 “Full-Scale Watershed Planning Investigation Memorandum” (AECOM, 2023a, **Attachment N**). The field investigations included the following:

- Depth to groundwater at each location;
- Direction and velocity of groundwater flow;
- Soil stratigraphy and hydraulic conductivity in the potential vertical extent of PRB;
- Maximum feasible depth of direct push injection; and
- Groundwater chemistry and nitrate concentration.

Figure 4-5. Potential PRB Locations



The results of the investigation indicated that PRBs at Namequoit and Ridge Roads were infeasible due to the lithologic conditions present as well as low nitrate concentrations. Although a PRB at Briar Spring

was determined to be feasible, the Town of Orleans has decided not to pursue this site due to its proximity to areas planned for sewering. The Duck Hole PRB is a feasible location, and **Table 4-1** summarizes the results of the investigations at this site. Note that sewer load is the estimated flux based on the modeled septic system load for the capture zone. The value for sewer load shown in **Table 4-1** was developed in the 2006 Massachusetts Estuaries Project report (Howes et al., 2006).

Table 4-1. Duck Hole Flux Range (30 Foot Vertical PRB)

	Nitrate (mg/L)	Nitrate Flux (kg/yr)
Low Concentration	0.80	178
High Concentration	3.62	805
Estimated sewer load based on source strength	---	370

Duck Hole had six monitoring well locations and three elevations screened at each location. The lithological and groundwater chemistry conditions make this suitable for PRB installation. With a PRB length of 4,100 ft and a vertical extent of 83 ft the potential range of nitrogen flux is from 492 to 2,228 kg/yr. Assuming an 80% reduction in nitrate flux based on PRB performance, nitrate load removal would be between 394 kg/yr and 1,782 kg/yr. This location is recommended for further consideration.

Subsequent to the 2023 field investigations, Mayflower and Lockwood in the Pleasant Bay watershed were selected for further consideration based on their location relative to groundwater flows and their position in the watershed, which maximizes potential for intercepting and treating nitrogen in the groundwater. Additional investigations of PRB viability at these two locations are still needed and would require installation of PRBs on private roads. On March 15, 2019, AECOM submitted a Notice of Project Change on behalf of the Town of Orleans to MEPA in accordance with 301 CMR 11.10(1) that described full-scale implementation of PRBs, described the implementation of the Eldredge Park Demonstration Project, and outlined the Town's plans to evaluate additional sites for PRB implementation. MEPA approval was received on April 19, 2019 (**Attachment A**).

The next steps for potential PRB implementation include additional baseline field investigations at the Norseman site in the Nauset Watershed and Mayflower and Lockwood sites in the Pleasant Bay Watershed, as well as final design of the Duck Hole PRB.

4.3.6 PRB Environmental Impact

The proposed PRBs would be located below-ground within existing roads, with the no permanent above-ground infrastructure. Therefore, impacts are minimal. Duck Hole is located partially within the Pleasant Bay ACEC and partially within an area mapped as a Natural Heritage and Endangered Species Program (NHESP) Estimated and Priority Habitat. The site is also located partially within FEMA Zone AE (100-year Floodplain) and partially within the 100-foot Buffer Zone of a Salt Marsh. The Mayflower and the Lockwood sites are located within the Pleasant Bay ACEC and partially within FEMA Zone AE (100-year Floodplain).Based on existing mapping, PRBs are not anticipated to be located within buffer zones of wetland resource areas, however, this will be confirmed during design. If needed, consultation with the Orleans Conservation Commission will occur regarding the need for filing a Request for Determination or Notice of Intent for construction of the PRBs.

4.4 Nitrogen Reducing Biofilters

Nitrogen reducing biofilters (NRBs) were the innovative/alternative (I/A) septic system evaluated by the Town of Orleans to determine the efficacy in managing nitrogen at its source. I/A systems in general, including NRBs, reduce the amount of nitrogen entering the environment from the discharge from on-site sewage disposal systems by addressing it locally. The system is effectively an innovative alternative for septic systems to reduce nitrogen concentrations from wastewater discharge. The system consists of a horizontal layer of sandy soils overlaying a layer of sand mixed with finely ground wood that is dosed with septic tank effluent using a low-pressure system. The technology was initially piloted at the Barnstable County Test Center and site-specific testing at individual lots was determined to be warranted.

A “Site Characterization and Evaluation Technical Memorandum” (AECOM 2016g; **Attachment O**) recommended that up to four sites be considered for demonstration in 2017 in Orleans. Over 50 sites were identified and 20 of those were evaluated. The Orleans Board of Health further evaluated 10 of those locations as potential demonstration sites. However, no suitable demonstration sites were found due to:

- Property owners not having the time available to permit the system with state and local agencies;
- Insufficient area available;
- Unsuitable soil conditions;
- Unsuitable site topography;
- High groundwater elevations;
- Proximity of wetlands

NRBs were dropped from consideration after no suitable demonstration sites could be identified and upon further consideration of relative cost effectiveness, I/A systems are unlikely to provide a cost-effective alternative as based on the results of a Pleasant Bay Alliance study (Horsley Witten Group, 2020; **Attachment P**).

5. Adaptive Management

The 2010 CWMP/SEIR included an Adaptive Management Plan 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. An Adaptive Management approach to wastewater management continues to be incorporated in this ACWMP to allow for ongoing evaluation, modification, and implementation of the proposed Non-traditional Technologies as well as non-structural solutions to nitrogen loading. The updated Adaptive Management approach is described in this Section and includes the following:

- Incorporation of NT Technologies
- Considerations for growth
- The Pleasant Bay Alliance and Associated Watershed Permit
- Town of Orleans water quality monitoring data
- Pochet Neck Nitrogen Attenuation Study
- Namskaket Marsh monitoring
- Other studies completed between 2016 and 2017
- Freshwater ponds nutrient management
- Stormwater, fertilizer, and herbicide management
- Regional coordination with Eastham and Brewster

5.1 Recommended Non-Traditional Technologies

In addition to traditional wastewater collection and treatment, multiple NT Technologies were evaluated through the OWQAP process and initially selected for implementation through the Consensus Plan (**Attachment C**). As discussed in Section 4, the following four NT Technologies were evaluated in detail through initial site investigations and development of work plans: floating constructed wetlands (FCWs), aquaculture, permeable reactive barriers (PRBs), and on-site nitrogen reducing biofilters (NRBs). As detailed in Section 4, only aquaculture and PRBs were further investigated through demonstration projects, and both are proposed for long-term implementation. In addition to continuation of the PRB at Eldredge Park, the use of PRBs is planned for additional investigation at four locations (Norseman, Duck Hole, Mayflower, and Lockwood), and aquaculture will be continued at Lonnie's Pond

5.2 Growth

Development growth within the Town of Orleans is difficult to predict and subject to a myriad of factors all of which cannot all be anticipated. Thus, the Adaptive Management approach allows for course corrections in the future to address this uncertainty. Orleans has experienced a growth rate of approximately 3.9% over the past 20 years and is planning for a similar growth rate in the future. As part of its wastewater management planning, a Build-Out Analysis for the Town center study area was completed which guided the planning of anticipated wastewater flows for Phase I Downtown Sewering (AECOM, 2016i). In addition, a technical memorandum was prepared, outlining strategies to manage growth and regulations, aimed at obtaining zero interest funding through the MassDEP Clean Water Act State Revolving Fund (SRF; AECOM, 2016h). At the May 8, 2017, Town Meeting, the Town introduced a proposed zoning bylaw entitled "Article 40 Amend Zoning Bylaws Section 164-31. Apartment Development" for a vote. The amendment provides reductions to minimum lot size requirements for apartment development as well as increased residential density (i.e., number of dwelling units per acre). The amendment allows further increased residential density for projects that support community goals, which include providing one-bedroom dwelling units, affordable housing units, and preservation of "significant" (i.e., historic) buildings. 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. The Town passed the amendment to Section 164-31 Apartment Development of the Zoning By-laws, which encourages the higher residential density that is desired in the Village Center district. The zoning amendment also includes residential density incentives for housing developments that 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, the Town was required to adopt land use controls that would limit any increase in wastewater flows as a consequence of changed land uses or increased density allowed if sewers are installed. The Planning Board took this requirement into consideration during development of the apartment development zoning amendment, which was passed at the May 2017 Town Meeting. The recommended plan will meet the MassDEP flow-neutral criterion for State Revolving Loan (SRF) funding eligibility. The Town is committed to re-evaluating growth prior to implementing every sewer phase to make sure that the sewering continues to meet the growth neutral requirements for SRF funding.

5.3 Pleasant Bay Alliance

5.3.1 Water Quality Data

The Town of Orleans has been a part of extensive collaborative efforts with Harwich, Chatham, and Brewster through the Pleasant Bay Watershed Alliance (PBA) to address excess nitrogen loading into Pleasant Bay. The PBA was formed in 1998 to oversee resource management planning for Pleasant Bay. Water between Pleasant Bay and the Atlantic Ocean is currently exchanged through two tidal inlets. The South Inlet was formed in 1987, and the 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.

For the past twenty-one years, the PBA has organized and trained volunteers to collect water quality data from 34 sampling stations bay-wide, which are sampled two times per month during July and August and once in early September. Water quality samples are collected in accordance with a Quality Assurance Project Plan (QAPP) developed for the Massachusetts Estuaries Program (MEP) by the University of Massachusetts Dartmouth SMAST (UMass SMAST, 2003). Periodically the PBA contracts with a firm to conduct a statistical analysis of water quality data trends in the Bay. The most recent analysis was in 2015 when the PBA contracted the Cadmus Group to analyze the monitoring data for statistical changes over time since a 2007 breach of the barrier island that separates Pleasant Bay from the Atlantic Ocean.

To evaluate water quality trends, the Cadmus Report analyzed water quality data at both individual water quality monitoring stations and bay-wide. The specific parameters include:

- Dissolved inorganic nitrogen (DIN)
- Bioactive nitrogen (BioN)
- TN
- PO_4
- Total phytopigments
- DO
- Salinity

This data analysis for Pleasant Bay monitoring stations includes the following 13 stations in Orleans:

- 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)
- Little Quanset Pond (WMO-12)

The Cadmus report concluded that the Pleasant Bay system is characterized by complex water quality trends. None of the parameters analyzed exhibited consistent trends across all monitoring stations or

within a given monitoring station. Bay-wide, however, all parameters except salinity showed significant trends. The trends for all parameters changed following the 2007 Nauset Beach break, except for DIN, which showed a significant increasing trend both before and after the breach (Cadmus, 2015).

5.3.2 Watershed Permit

In 2018, the PBA applied for and received a Watershed Permit from MassDEP to address nitrogen impairment within Pleasant Bay. This permit is the first of its kind and requires the four watershed towns (Brewster, Chatham, Harwich, and Orleans) to work collaboratively under the 2018 Pleasant Bay Targeted Watershed Management Plan (TWMP) (Pleasant Bay Alliance, 2018) to address excessive inputs of nitrogen into receiving waters and reach TMDL compliance. **Table 5-1** illustrates the Implementation Plan included in the TWMP and identifies the measures that each Town plans to complete to meet their respective nitrogen removal commitments. In addition to monitoring and reporting of water quality, the TWMP includes implementation of aquaculture projects (Lonnie's Pond), sewering, on-site denitrification systems and fertilizer reduction across the municipalities. The basis for Orleans' technology selection in the current Watershed Permit is that the OWQAP placed a strong emphasis on the evaluation of the ability of NT Technologies to meet the TMDL requirements for Pleasant Bay. However, the ACWMP is now proposing further sewering as a component of Orleans' plan to meet TMDL requirements. Overall, the Watershed Permit gives participating municipalities a framework by which they can conduct nitrogen mitigation efforts and includes an opportunity to obtain nitrogen reduction credits from MassDEP. In total, the Management Plan suggests that 17,717 kg a year of nitrogen will need to be removed across the entire watershed to meet TMDL requirements. The Pleasant Bay Alliance, member towns, and UMass Dartmouth School for Marine Sciences and Technology worked together to update the Pleasant Bay Massachusetts Estuary Program (MEP) model. The results showed that the nitrogen removal strategies in the PBA Targeted Watershed Management Plan would meet TMDL thresholds and that alternative scenarios would also meet the TMDL (Howes et al., 2021). The most recent PBA Annual Report (Pleasant Bay Alliance, 2023; **Table 5-2** documents that Orleans has achieved 60% of its nitrogen removal target for 2023, and that overall, the four towns have achieved 91% of the 2023 goals. The 2023 PBA report notes that Orleans nitrogen reductions to date have been accomplished through its residential fertilizer control ordinance and Lonnie's Pond aquaculture and notes the Phase 2 Meetinghouse Pond sewering under construction and upcoming Phase 3 Lakes and Pond sewering will accomplish over 2,000 kg/yr of nitrogen removal. The PBA is currently entering into the second five-year planning cycle of the Watershed Permit, and the Town of Orleans will continue to be an active member of this planning. This ACWMP will be the principal resource for formulation of a new plan for Pleasant Bay, which must be incorporated into the Year-6 permit update.

The Town is preparing modifications to its Pleasant Bay technology plan for inclusion in the 2024 update of the Watershed Permit. That revised technology plan will build on the Sewer Master Plan developed under the ACMP and is expected to also include allowances for growth in the watershed nitrogen loads and a range of water use estimates that drive the septic nitrogen loads.

Table 5-1. Pleasant Bay Association 2018 Targeted Watershed Management Plan Implementation

			Brewster		Chatham		Harwich		Orleans		Total
Phase	Years		Activity	kgN/yr*	Activity	kgN/yr*	Activity	kgN/yr*	Activity	kgN/yr*	kgN/yr*
	up to 2018		Res. fertilizer control Capt GC fertigation Capt GC fert. reduction	121 230 930	Res. fertilizer control Muddy Creek Bridge	247	Muddy Creek Bridge		Res. fertilizer control	241	1,769
			All towns: develop TWMP; demonstrate 208 consistency; execute IMA; obtain Watershed Permit								
1 **	1 to 5	2019 to 2023	Develop denit plan Devel. conting. plan Strengthen GC plan		Harwich connection		Ph 2 sewers Res. fertilizer control	2,672 200	Amended CWMP Lonnie's Pond aqua. PRB evaluation	273	3,145
			All towns: update monitoring data, re-model Bay, evaluate nitrogen trading options, prepare plan for next 5 yr								
2 ***	6 to 10	2024 to 2028	On-site denit systems	118			Ph 3 sewers	1,565	MtgHouse Pond sewers Other aquaculture On-site denit systems	2,014 1,516 674	5,887
3 ***	11 to 15	2029 to 2033	On-site denit systems	118	Frostfish Creek sewers Ryders Cove sewers	803 2,605			On-site denit systems Other aquaculture	675 906	5,107
4 ***	16 to 20	2034 to 2038	On-site denit systems	118	Muddy Creek sewers	1,597			On-site denit systems	675	2,390
	after year 20	after 2038	On-site denit systems	236	Crows Pond sewers Bassing Harbor sewers Pleasant Bay sewers Chatham Harbor sewers	1,214 511 901 5,181	Ph 8 sewers Harwich effl. disposal	970 (867)	****		8,146
			Total	1,871	Total	13,059	Total	4,540	Total	6,974	26,444

* Removals pertain to current nitrogen loads without growth, and represent estimates of removal potential.

** First Phase (Years 1 to 5) includes activities that are firm commitments by the towns and are necessary to gain DEP enforcement discretion.

*** Phases 2 through 5 (Years 6 to 20) include activities that are now planned and considered enforceable until such time as they may change depending on the outcomes of Phase 1 and application of each town's adaptive management program, as per the Watershed Permit.

**** The discharge of Harwich effluent within the Pleasant Bay watershed may become necessary if alternative disposal sites are not developed.

Table 5-2. Summary of Nitrogen Removal Achievements and Goals

	Brewster		Chatham		Harwich		Orleans		Total Load Removal
	Activity	Load	Activity	Load	Activity	Load	Activity	Load	
Nitrogen Load Removals Accomplished Prior to Watershed Permit, kg/yr	Res fertilizer controls GC fertilizer controls	121 1,160	Res fertilizer controls	247	None	-	Res fertilizer controls	241	1,769
New Nitrogen Load Removals Accomplished in FY 2019 to FY 2023, kg/yr			Frostfish Ck and Muddy Ck sewers	520	E. Harwich sewers * Res fert. controls	1,906 200	Lonnie's Pond pilot shellfish harvest **	67	2,693
Cumulative Nitrogen Load Removals Accomplished by end of FY 2023, kg/yr		1,281		767		2,106		308	4,462
2023 Goals, kg/yr		1,281		247		2,872		514	4,914
Accomplished by 2022, %		100%		262%		63%		63%	82%
Accomplished by 2023, %		100%		311%		73%		60%	91%
20-yr Goal (2038), kg/yr		2,262		4,076		4,399		6,980	17,717

* Sewers are constructed; tie-ins expected over next 2+ years
** Harvest data may change pending results of pilot project
*** Attenuated loads removals may be adjusted by ongoing re-evaluation of attenuation rates

5.4 Town of Orleans Water Quality Monitoring Data

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. Pleasant Bay water quality data are discussed above in Section 5.3.1. The Orleans Marine and Freshwater Quality Task Force (OWQTF) organizes volunteer water quality sampling in Town Cove. Volunteers collect samples in compliance with the UMass Dartmouth SMAST Quality Assurance Plan (QAPP; UMass Dartmouth SMAST, 2003) and these data are collected and analyzed annually by UMASS Dartmouth SMAST.

The Nauset Harbor MEP Report utilized 2001 – 2004 water quality data obtained at 15 sampling stations. Upon receipt of the Nauset MEP Report in 2012, the Towns (Orleans and Eastham) reduced sampling to 3 sentinel stations. In 2016, Orleans and Eastham increased the number of sampling stations to 12 at the direction of SMAST staff to enable a future updating of the MEP model. That level of sampling has continued through the 2023 summer sampling season.

Recorded water quality parameters contained in the data sets for Nauset Harbor include:

- Weather
- Wind Force
- Wind Direction
- Water Condition
- Secchi Depth
- Salinity
- Field Corrected Salinity
- Sample Time
- Sample Depth
- In Situ Dissolved Oxygen
- In Situ DO (As Percent Saturation)
- In Situ Water Temperature
- Laboratory Salinities
- Laboratory Conductivity
- SRP
- Ammonium (NH_4)
- Nitrate (NO_3)
- DIN
- DON
- Total Dissolved Nitrogen
- PON
- Total Organic Nitrogen (TON)
- TN
- Particulate Organic Carbon
- Chlorophyll a (CHl-a)
- Pheophytin

Several of these parameters, 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.

Currently, the Town is working to organize and simplify the existing data to illustrate data trends. The goal of this initiative is to make the robust water quality dataset digestible for a public audience. A scope of work is currently in progress for this plan, which should be fully implemented in the spring of 2024. The existing Town dataset is not intended to support a TMDL. Rather, the existing data acts as a tool to illustrate trends in water quality and nutrient loads. Analysis of existing data will inform the focus of future monitoring, as analysis of current/historic trends will allow for the identification of target areas for more focused monitoring. One factor of particular concern that has been considered by the Town is climate change. The in-depth tracking of water quality will be an important tool in identifying the impacts of future change in coastal ecosystems. Such monitoring will allow for informed decision-making when it comes to these coastal systems. The baseline water monitoring data will also be available as decisions are made about final nitrogen removal goals for the receiving water bodies. it is anticipated that these future TMDLs

will be focused on the nitrogen concentration in the water column. This is due to nitrogen being a leading contributor of nutrient loads in receiving waters. Identifying areas with excessive concentrations of nitrogen presents the most efficient way for establishing and managing TMDLs in receiving waters and is the first step in addressing impaired ecosystems. The end goal of the establishment of the TMDLs is to facilitate habitat restoration, which can be affected by multiple factors other than nitrogen. Therefore, a robust set of parameters is recorded when tracking water quality.

5.5 Pochet Neck Nitrogen Attenuation Study

The University of Massachusetts Dartmouth Coastal Systems Program of SMAST (CSP/SMAST) is currently completing a nitrogen attenuation study to measure the nitrogen exchange at the inlet to the Pochet Neck System in the upper reaches of Pleasant Bay in order to better understand nitrogen inputs from salt marshes in this area. CSP/SMAST initially completed nitrogen mass exchange measurements over three tidal cycles in the Summer of 2022. These initial results indicated that no nitrogen attenuation was provided by the Pochet Neck System and that there were higher rates of nitrogen released in the rest of the Pleasant Bay Watershed. Under the current study, additional monitoring is being completed in the salt marsh north of Pochet Road. Water quality sampling occurred over three tidal cycles in July, August, and early September 2023 and the analysis of the results is still underway. Findings will be compiled in a technical memorandum and submitted to the Pleasant Bay Alliance in early 2024. The results of the study will be reviewed and may be used to adjust the sewering approach for homes in the study area. The Pochet Neck residential area is currently proposed for sewering in Phases 9 (Pochet West), 10 (Pochet East), and 11 (Pochet North) allow time for review and consideration of the study results and how they may affect estimates of nitrogen loading in this area.

5.6 Namskaket Marsh

Namskaket Marsh is an 80-hectare (200 acre) salt marsh on the northeastern coast of Cape Cod, located within the towns of Orleans and Brewster. The Marsh has been designated by the state as an ACEC because of the unique environmental resources in need of special management attention. The Namskaket Marsh has also been designated as an Outstanding Resource Water (ORW) by the State because of its “outstanding socio-economic, recreational, ecological, and/or aesthetic values”. As such, these waters are given special protection under the Massachusetts Surface Water Quality Standards.

The watershed is bifurcated by an elevated bike trail, creating, in conjunction with other watershed changes, an upper and lower marsh with distinctively different characteristics. According to the MEP Report, the lower marsh is characteristic of

> “...a typical New England salt marsh dominated by a central tidal creek and emergent marsh colonized by low marsh and high marsh with some more brackish marsh plants found in the upper-most regions and limited bordering patches of phragmites. Tidal exchange with the high-quality waters of Cape Cod Bay is high, given the ca. 10-foot tide, which has also resulted in tidal creeks which are deeply incised, with near complete drainage at low tide. The result is the type of coastal system which has a relatively high tolerance for nitrogen inputs from its watershed.” (UMass Dartmouth SMAST, 2008)

On the other hand, the upper marsh has been affected by urbanization, including significant commercial development, transportation systems, and utilities with related severe negative modifications to the stormwater drainage patterns and resulting groundwater recharge and pollutant loading to surface waters. During the development of the 2010 CWMP, the paramount concern was the potential for excessive enrichment of the marsh due to on-site wastewater discharges, the Tri-Town Septage Treatment Plant (TTSTP) discharge, stormwater runoff, and other sources. Consequently, these issues were addressed in detail in the monitoring, modeling, and resulting Massachusetts Estuaries Project analyses performed as part of the 2010 CWMP process.

Due to the special protection warranted by the ACEC and ORW classification, the Town of Orleans opted to investigate alternative locations for discharge of the treated effluent from the new WWTF proposed in the CWMP/SEIR. The new WWTF will discharge up to approximately 700,000 gpd upon full implementation of the CWMP. The historic 20-year average discharge from the former TTSTP located on Overland Way just north of the bike path was approximately 30,000 gpd.

During and after the development of the 2010 CWMP/SEIR, additional concerns were raised regarding the effect of the proposed WWTF discharge at Overland Way on Namskaket Marsh due to historic concerns regarding the TTSTP discharge. Concerns noted were:

- The potential influence of the discharge of treated wastewater from the TTSTP. Specifically, the concern that the treated freshwater comprising the groundwater discharge had potential to upset the natural fresh-saline water balance in the estuary, affecting vegetation and aquatic habitat downstream.
- Alterations in vegetation patterns due to freshwater discharges from the existing TTSTP, as well as alterations in the hydrology of the watershed due to urbanization of the area up-stream of the bike path.

To address these concerns two additional studies were undertaken by the Town:

- A 2016 study by the United States Geologic Survey (USGS) compared the historic groundwater conditions, including nitrogen and salinity concentrations, with conditions 20 years after beginning of operation of the TTSTP.
- A 2016 SMAST salinity and vegetation survey of the marsh downstream of the bike path updated their previous 1995 study to define changes in the characteristics of the marsh with respect to those parameters.

The USGS study report concluded that there was no evidence that 2011 Namskaket creek samples showed any evidence of elevated nitrate or total dissolved nitrate attributable to the TTSTP discharge (USGS, 2016).

The SMAST vegetation and salinity study report concluded that:

> “Upper Namskaket Marsh is a dynamic system that has experienced changes over the past 2 decades. However, the direct measurements do not support the contention that the invasive plant Phragmites australis has increased its distribution and abundance within Upper Namskaket Marsh from 1995 to 2015”. Instead, SMAST concluded that the vegetation changes observed were due to natural cycles of wrack deposition removal, and resultant vegetation shifts (SMAST, 2016).

5.6.1 Salt Marsh Vegetation Monitoring

As discussed in Section 3.1 and in the 2018 NPC submitted to MEPA, the location of the new WWTF effluent discharge was changed from rapid infiltration beds at Overland Way to wick wells at 32 Lots Hollow Road. The groundwater mounding simulation completed for the MassDEP-approved Hydrogeologic Report indicates that a rise of approximately 0.3 feet at a discharge of 150,000 gpd, and a rise of up to 1.0 foot at a discharge of 500,000 gpd, may occur at the eastern/southeastern boundary of Namskaket Creek. Similarly, the groundwater model predicts a potential rise of approximately one inch at 150,000 gpd discharge to four inches at 500,000 gpd discharge at Little Namskaket and north of Namskaket Creek.

Although this groundwater mound prediction is only an approximation, the increase in groundwater elevation in the vicinity of Namskaket and Little Namskaket Creek has the potential to alter the hydrology of the marsh sufficiently that a vegetation change may occur. The portion of the Namskaket Creek that is within the area of the predicted groundwater mound is an area which includes both a saltmarsh as well as a brackish plant community associated with Hurley’s Bog.

Typically, the hydrology driving the presence of hydrophytic plant species is located within the top 12-inches of the soil; therefore, a change in this regime of 3 to 12 inches could result in a substantial change to the hydrological conditions experienced by plant species present. Since the discharge would represent an increase in freshwater input to the marsh, it is possible that a shift from salt marsh to freshwater plant species could occur. These conditions would be particularly favorable to an increase in extent of Phragmites, which already exists in the area (SMAST, 2016). The extent of any vegetation shift is difficult to predict. Therefore, monitoring of the plant species distribution within the eastern/southeastern portion of Namskaket Creek was recommended just prior to and immediately following the discharge commencement, in order to document any shifts in plant cover from salt water to freshwater species, including Phragmites. The MassDEP May 9, 2019, Hydrogeologic approval letter and September 27, 2021, Modification letter (**Attachment F**) Condition #4 states: "*There is possible impact of mounding on the marshes; therefore, monitoring of the species present is recommended prior to discharge to document any potential changes during discharge commencement*."

Salt marsh vegetation monitoring was conducted to assess plant species distribution within the eastern and southeastern portion of Namskaket Creek. The goal of the monitoring is to document any shifts in plant cover from salt marsh to freshwater vegetative species over time, including Phragmites. The first year of monitoring was conducted on July 21 and 22, 2022. A second round of monitoring occurred July 26 and 27, 2023 shortly after initiation of discharges at the 32 Lots Hollow wick discharge site. The data collected in 2022 and 2023 will be used as a baseline to determine potential effects of discharged treated sewage effluent. The results of the baseline monitoring data are compiled in the 2022 and 2023 Namskaket Monitoring Reports (AECOM 2022, 2023b) (**Attachment Q** and illustrated in **Figure 5-1**and **Figure 5-2**).

The monitoring consists of eight permanent vegetation monitoring plots. The plots are located on the edges of different plant communities; the edge of established communities are more likely to show initial change in vegetation distribution and percent cover. Each plot is a 20-foot diameter radial plot which can be reevaluated in the future if needed to assess vegetation changes. The vegetative species present and the total percent cover of each species were recorded and compared between years. Additionally, a small Unmanned Aircraft System (i.e., drone system) was used to document vegetative species assemblages aerially via an orthophoto mosaic (**Figure 5-1** and **Figure 5-2**). The monitoring conducted illustrates that although natural processes of wrack deposition and removal affect the salt marsh species coverage, the native salt marsh vegetation is currently healthy and robust.

Figure 5-1. Namskaket Marsh Vegetation Monitoring Vegetation Cover Types, 2022

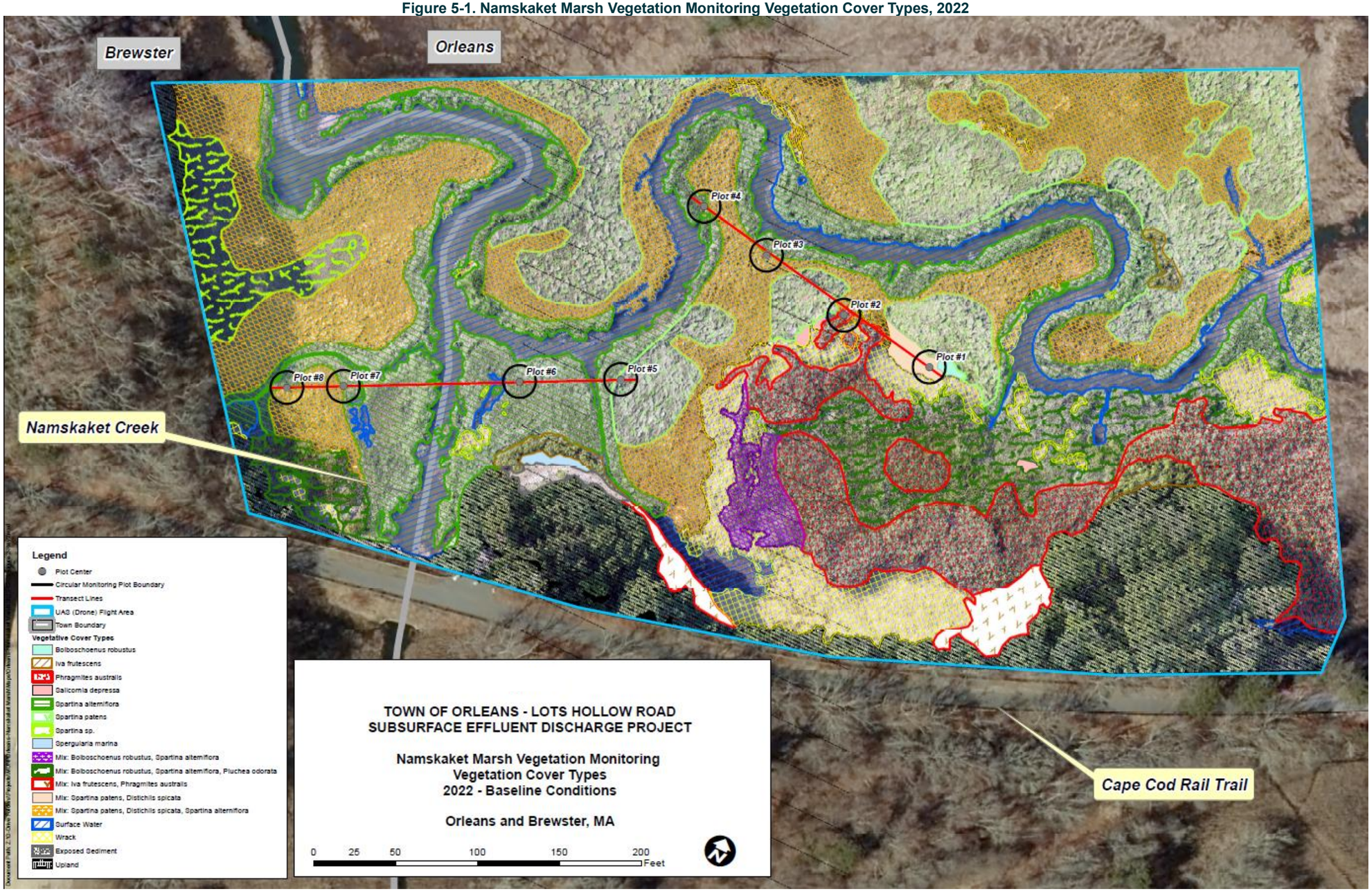
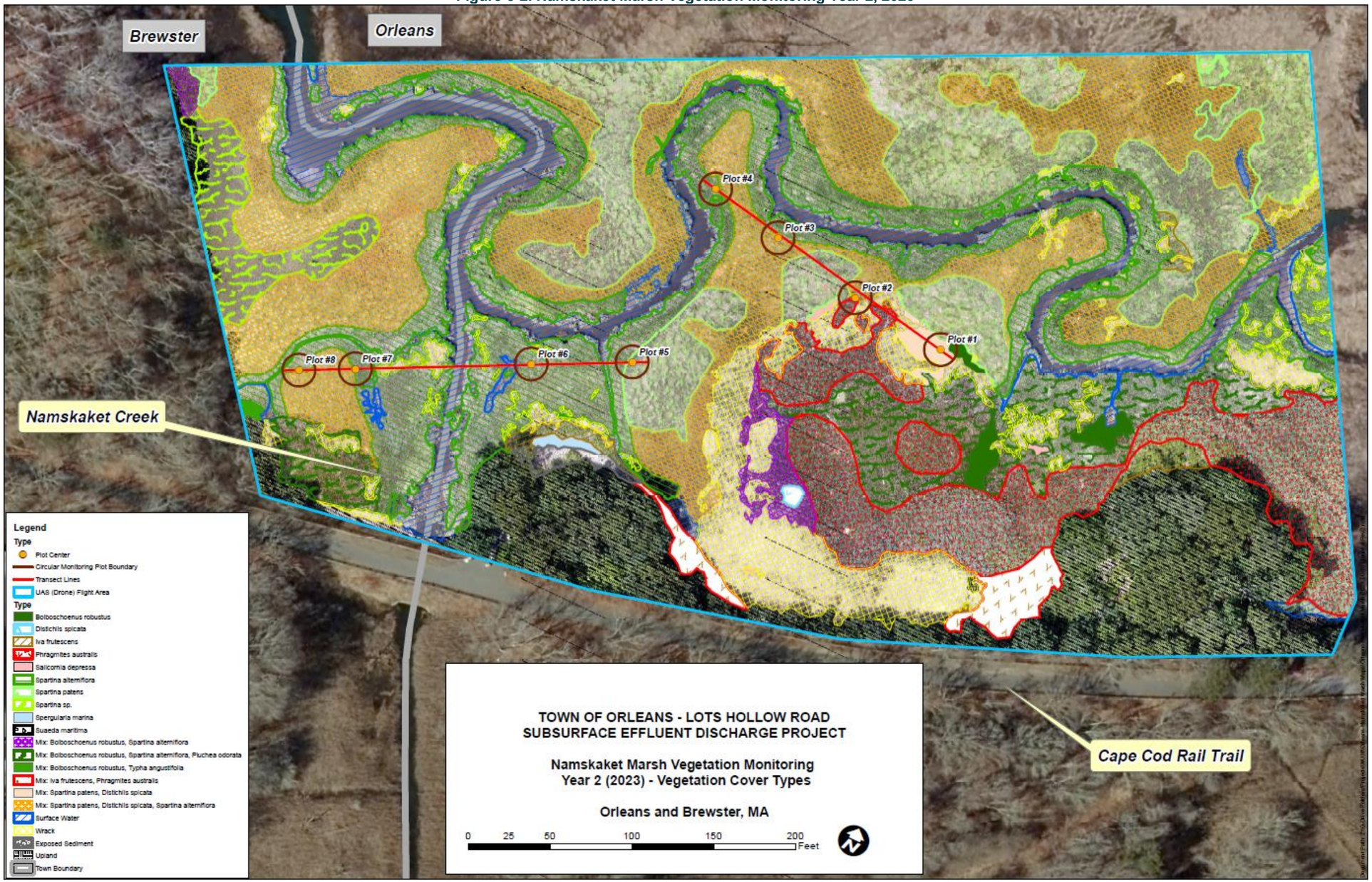


Figure 5-2. Namskaket Marsh Vegetation Monitoring Year 2, 2023



5.7 Other Studies Completed Between 2016 and 2017

Between 2016 and 2017, numerous studies were completed, and technical memoranda prepared as part of the Orleans Water Quality Advisory Panel (OWQAP) review and analysis of approaches to manage wastewater and nutrient loading. Some of these are summarized in Section 4 and describe approaches that the Town is advancing. Additional studies, some of which now include outdated and/or superseded information, are summarized below in **Table 5-3**. These studies and technical memoranda document the extensive work that the Town of Orleans has completed to explore various avenues for nitrogen removal to reach compliance with nitrogen removal goals identified in the Pleasant Bay TMDL and MEP reports for Rock Harbor and Nauset Harbor.

Table 5-3. 2016-2017 Technical Memoranda Summaries

Technical Memorandum	Date	Description
Updated Downtown Build-Out Analysis and Land Use/Market Conditions and Development Constraints	13-Mar-16	Presents 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.
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	4-May-16	Presents the methodology and the results of future build-out scenarios for the Town Center Study Area, as well as strategies to manage growth, draft regulations to obtain zero interest financing, and implications for wastewater loading impacts and other community impacts in the Town Center Study Area.
Zoning Bylaw Amendment for Apartment Development (Section 164-31 & 164-34B)	8-May-17	Reduces the minimum lot area for apartment development and allows for increased residential density.
Management of Future Downtown Wastewater Flows and Biosolids	22-Jun-16	Presents the proposed management of wastewater flows and biosolids associated with the future preferred Build-Out Scenario for the Town Center Study Area.
Collection System Technologies (GS, LPS, STEG, STEP, and VS)	21-May-16	Identifies the types of collection system technologies and evaluates each of the technologies to develop a cost-effective alternative for the proposed Downtown and Meetinghouse Pond Wastewater Collection Areas of Orleans.
Wastewater Treatment, Residuals, Septage Management, Effluent Transmission and Pumping Components of the WWTF	4-Apr-16	Defines the appropriate array of technologies for the treatment of wastewater, includes the management of treatment plant residuals, septage, and the conveyance of treated effluent to its ultimate disposal location.
Water Reuse Systems	22-Jun-16	Discusses 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.
Adaptive Management Plan, Water Quality Monitoring and Modeling: Consolidation and Comparison of Baseline Monitoring Data Sets	4-May-16	Evaluates the adequacy of sampling locations and methodology in order to establish baseline conditions, determine data gaps, and inform future monitoring.

Technical Memorandum	Date	Description
Shellfish Cultivation - Preliminary Engineering Design and Work Plan for Preferred Site(s)	4-May-16	Presents the preliminary design for four different shellfish demonstration projects.
Adaptive Management Plan, Recommendations for Long Term Water Quality Monitoring Plan	4-May-16	Describes Orleans' current monitoring programs, and compares data collected since 2003 to the data reported in the MEP Reports for Pleasant Bay and Nauset Harbor.
Adaptive Management Plan, Non-Traditional Technology Performance Analysis	16-May-16	Presents a systematic program for monitoring three non-traditional water improvement technologies: Shellfish, FCWs, and PRBs in ponds and estuaries in the Town of Orleans.
Evaluation of SRF and Other Financing Options	20-May-16	Presents a high-level overview of financing options for Orleans' Wastewater Program. This document discusses financing available through the Massachusetts Clean Water State Revolving Fund program, USDA, and conventional financing.
Aquaculture Full-Scale Implementation Program	07-July-17	Presents a planning-level overview of the species, quantities, and growing paradigms for removing nitrogen loads from both Pleasant Bay and Town Cove using shellfish.

5.7.1 Landfill Nitrogen Plume

The former Orleans landfill consisted of approximately 21 acres of Town-owned land located off Lots Hollow Road. The property included a natural kettle hole that was used for solid waste disposal from the 1950s until 1991. The property also included an active solid waste transfer station and a yard waste composting and stockpile area. Six unlined septage lagoons, used between 1950 and 1989, were located north of the capped solid waste area. The landfill's stormwater control system included a perimeter swale around the entire property and a 108,000 cubic foot (808,000 gallon) capacity retention basin located in the northeast corner. The retention basin included a sediment forebay and was designed to fully control a twenty-five-year storm event prior to discharge through an emergency spillway. A layout of the former Landfill and its stormwater management system is displayed in **Figure 5-3.**

In 2005, the unlined solid waste fill area was closed, and a 13-acre area was capped with a final cover system. After this disposal area was capped, a drainage swale was constructed to prevent continued infiltration of precipitation through the waste. Stormwater system modifications were planned for implementation during construction of the new Department of Public Works (DPW) and Natural Resources Facility at the landfill.

Nitrogen in the groundwater in the vicinity of the landfill has the potential to migrate into Town Cove and affect estuarine water quality. Nitrogen compounds (total nitrogen, nitrate, and ammonia) have been detected at significant concentrations in groundwater downgradient from the landfill and its former septage lagoons. Long term monitoring of four monitoring wells (MW-1S, MW-2S, MW-2D, and MW-5S) indicates groundwater nitrate concentrations greater than the Massachusetts regulatory limit of 10 mg/L, with a high concentration of 40 mg/L observed at Monitoring Well-2S. Four of the shallow landfill water table monitoring wells (MW-1S - MW-4S) were installed in 1992 as part of an assessment associated with the septage lagoon closure. Deeper screened monitoring wells (MW-1D, MW-2D, MW-3D, and MW-4D) were installed as part of the 1994 Landfill Comprehensive Site Assessment, completing the well couplets at these locations. One additional couplet (MW-5S and MW-5D) was also installed in 1994. Monitoring well couplet MW-E6B and MW-E6A was installed by AECOM in 2016 for a Nitrogen Assessment. **Figure**

5-4 shows the locations of monitoring wells at the landfill site. The landfill monitoring wells have been routinely sampled twice a year for nitrate, dissolved iron, manganese, and volatile organic compounds. Total nitrogen was added to the sampling plan starting in May 2015. Results of testing indicated that total nitrogen concentrations were significantly higher than nitrate concentrations in some of the deeper wells, while nitrate was dominant in shallow wells. In the 2012 Nauset MEP Report, the nitrogen load coming from the plume was estimated to be 119 kg/year (Howes et al., 2012).

The Landfill Nitrogen Assessment (AECOM, 2018c) discusses actions that can be implemented to reduce groundwater contamination and the flux of nitrogen migrating in groundwater from the Orleans Municipal Landfill toward Town Cove (**Figure 5-5** and **Figure 5-6**). The Landfill Nitrogen Assessment was completed in three phases of work.

Figure 5-3. Landfill Stormwater Management System

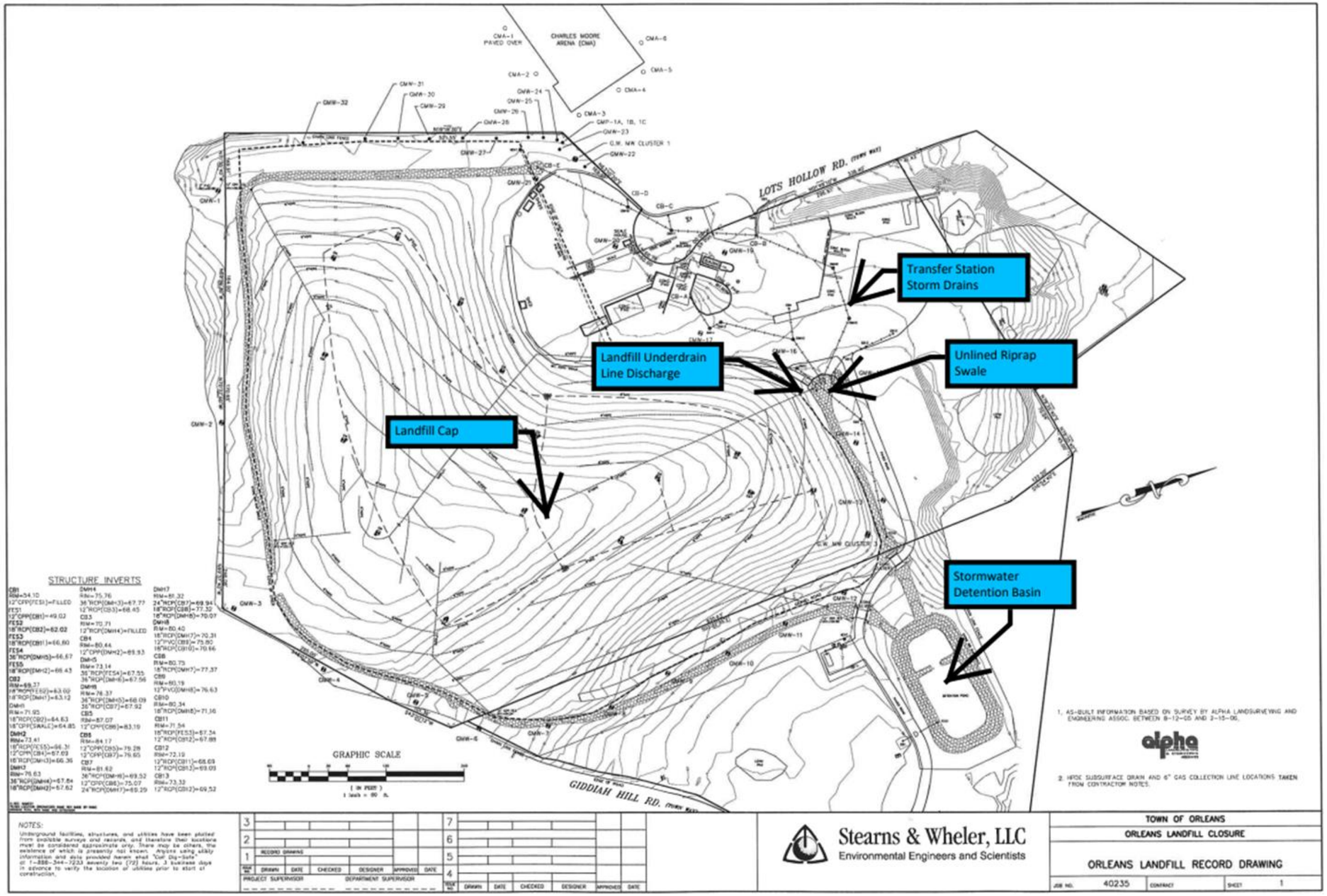


Figure 5-4. Town Landfill Monitoring Well Locations

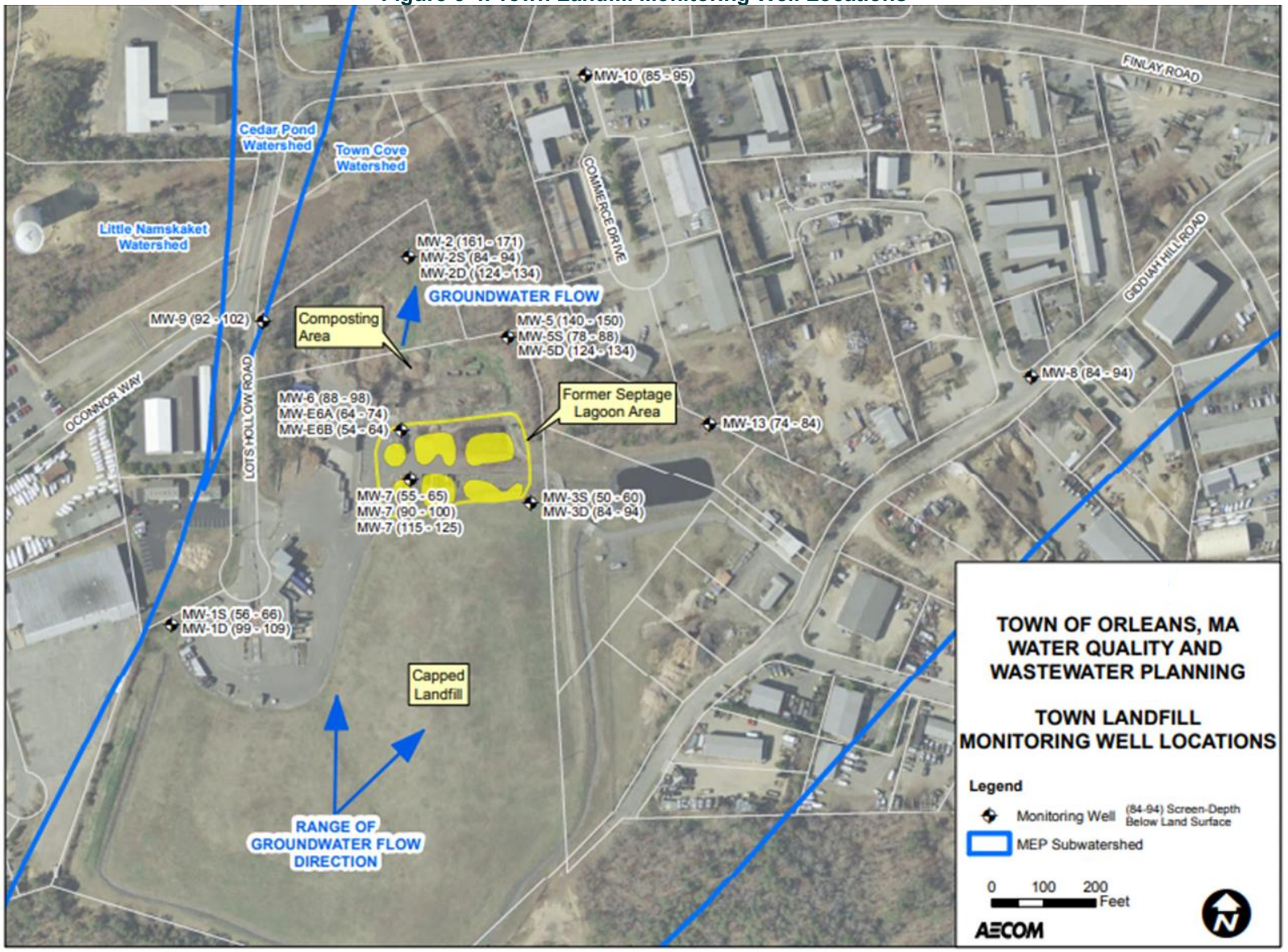


Figure 5-5. Landfill Groundwater Flow - Particle Tracking

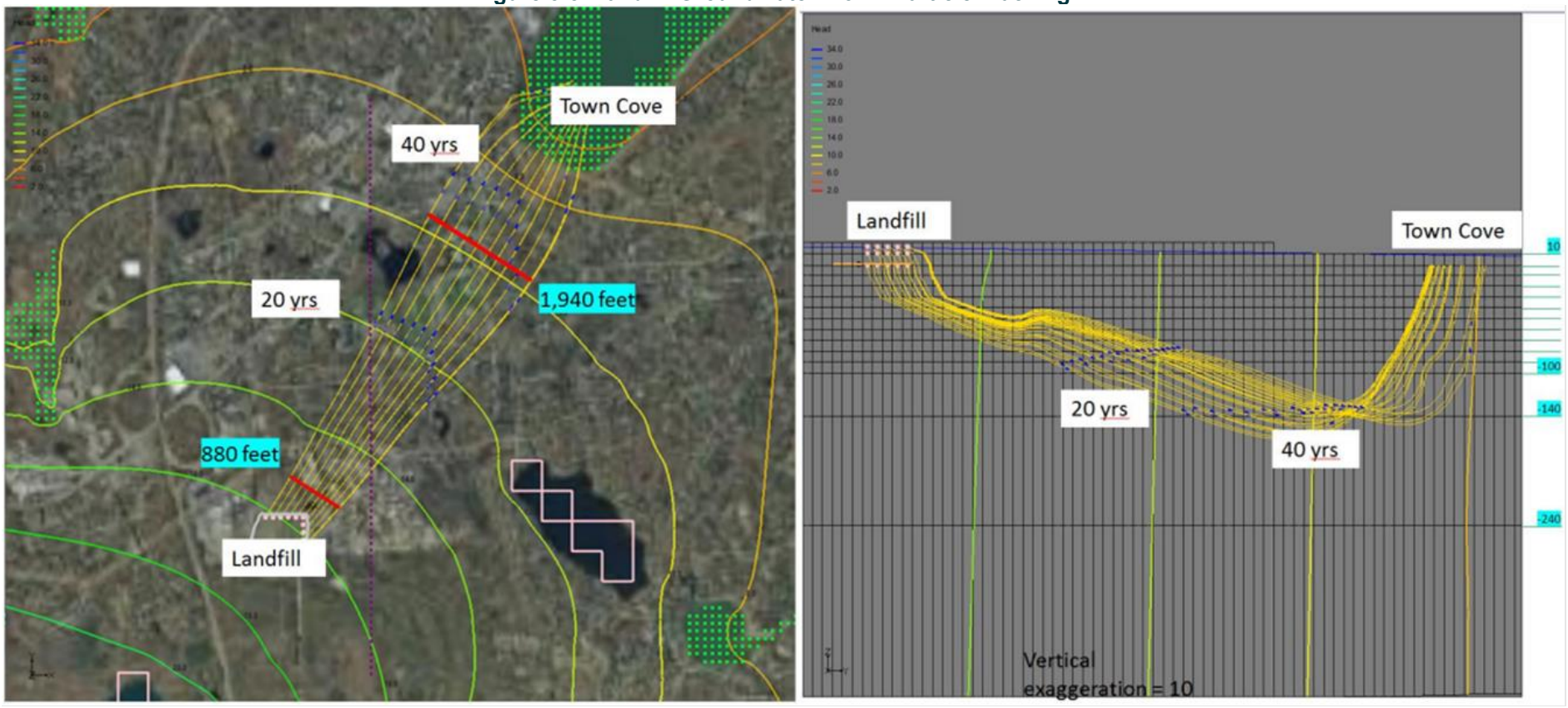
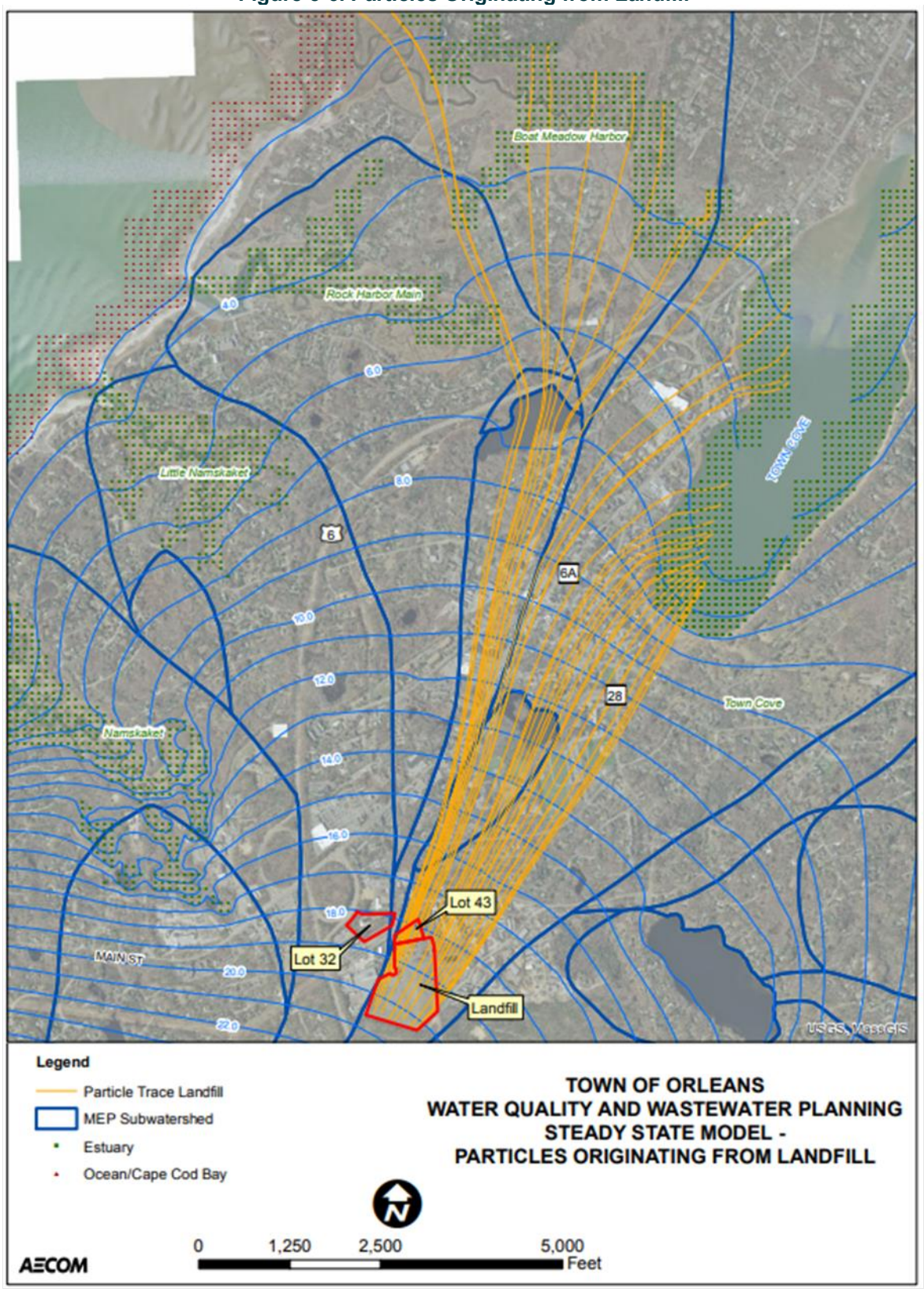


Figure 5-6. Particles Originating from Landfill



The four primary sources of nitrogen confirmed at the landfill and Transfer Station include:

1. **Solid waste**: Leachate from the capped solid waste landfill entering the groundwater.
2. **Compost operations**: Leachate from compost that either directly infiltrates through soil to groundwater or runs off to the Stormwater Management System.
3. **Infiltration through the former septage lagoons**: Residual nitrogen in the soil, from the former septage lagoon area, that is mobilized by the infiltration of precipitation and stormwater.
4. **Transfer Station and landfill runoff:** The runoff, from the Transfer Station and the landfill operations, includes nitrogen from multiple sources that is recharged into the groundwater.

A secondary source of nitrogen migrating to downgradient groundwater is the nitrogen (nitrate and ammonia) already in the groundwater at the landfill.

The unlined landfill is expected to continue to generate leachate that directly infiltrates into groundwater as the solid waste matures. Leachate generation is affected by landfill settlement, fluid movement, and biodegradation of wastes. No additional direct response actions beyond the completed cap and ongoing groundwater monitoring are considered feasible. Groundwater treatment to reduce mass discharge at the landfill would require a significant capital investment and the long-term operation and maintenance of treatment facilities. Removing nitrogen from groundwater at the landfill will not directly reduce nitrogen loading to Town Cove in the near term because of the time it takes for plume migration; which it is estimated at approximately 50 years for nitrogen in the form of nitrate (**Figure 5-5**), and upwards of 200 years for nitrogen in the form of ammonia. Nitrogen from the landfill may attenuate to some degree through natural processes as it migrates through the deep groundwater system towards Town Cove. The plume from the landfill is expected to dive deeper below the water table as it migrates toward Town Cove; the depth of migration in groundwater likely precludes direct assessment and response actions to intercept the nitrogen load in transit closer to Town Cove.

Response actions for other areas of the landfill corresponding to the above sources of nitrogen are listed below. Sewers in Phases 1,12,14, and 15 are in part designed to remove enough nitrogen to compensate for this plume,

- Added impermeable pavement and stormwater controls in the yard waste materials receiving area. DPW uses this space for receiving and initial storage of yard waste and then periodically transfer materials to a new composting operations area on the landfill cap. The benefits of this response action include a near term contribution to aquifer restoration by preventing further groundwater contamination in the source area and long-term benefit through reduced nitrogen migration in groundwater.
- Placed an impermeable pavement cover over the former septage lagoons area. The pavement cap reduces or eliminates infiltration through the residual septage material. The benefits of paving include a near-term contribution to aquifer restoration by preventing further groundwater contamination in the source area and long-term benefit through reduced nitrogen migration in groundwater.
- Replaced the unlined drainage swale on the north side of the landfill cap area with impermeable conveyance. The benefits of swale reconstruction include a substantial near-term contribution to aquifer restoration by preventing further groundwater contamination in the source area and long-term benefit through reduced nitrogen migration in groundwater.

5.8 Freshwater Ponds

Sixty freshwater lakes and ponds have been identified withing the borders of the Town of Orleans (by a Cape Cod Commission (CCC) survey). Volunteers, coordinated through the Orleans Marine and Freshwater Quality Committee (Committee), began collecting water quality data from these ponds in 2000. In 2001, local, regional, and state agencies began a concerted effort under the Pond and Lake

Stewardship Program to support volunteer monitoring, clean water advocacy, and developing a better understanding of the ecological health of Cape Cod lakes and ponds. Orleans volunteers collected over 600 water quality samples from 18 freshwater ponds in Orleans with 1,800 complementary field data points for four summers between 2002 to 2005. This data was analyzed and interpreted by Commission staff. The 2010 CWMP recommended that the Town systematically evaluate all of its major freshwater ponds to determine what other phosphorus controls are needed to supplement the reduction in wastewater loadings. Of the 18 ponds with water quality data, four were identified as high priority ponds and have since been addressed by pond management studies.

In December 2016, the Orleans Select Board authorized and funded the development of a plan for further evaluation, protection, and remediation of the freshwater ponds in the Town. The plan built upon and expanded the review of information and assessments completed under the 2010 CWMP. The plan also utilized the over 17 years of freshwater lake and pond data collected by and coordinated through the Marine and Freshwater Quality Committee.

The Committee reviewed and analyzed all the available water quality data for freshwater ponds. Data gaps were identified and utilized to develop management strategies and identify the ecological and prospective regulatory status of the Town's freshwater ponds. This work was contracted to CSP/SMAST by the Town.

Water quality management plans were developed for several ponds. Plans included watershed assessments, existing data gaps, stream flow monitoring, sediment characterization, shellfish surveys, and stormwater monitoring when applicable. Management plans also included restoration monitoring to confirm that the water quality and ecosystem goals were attained. Each plan also evaluated potential remediation and management alternatives to address the existing impairments and threats. This included regulatory requirements, costs, and implementation roles and responsibilities. Phosphorous reduction was identified as the goal for each pond. The status of the management plans developed to date, and corresponding actions are summarized below. :

The Association to Preserve Cape Cod (APCC) has gathered monthly water level readings from a dozen ponds on Cape Cod from May to September since 1973. Beginning in 2023 and running through 2025, the Cape Cod Regional Pond Monitoring Program, launched by CCC and the APCC, will be monitoring of fifty ponds on Cape Cod, three of which are ponds in Orleans – Reubens Pond, Crystal Lake, and Pilgrim Lake.

5.8.1 Uncle Harvey's Pond

Uncle Harvey's Pond was the first freshwater pond selected by the Marine and Freshwater Quality Committee for the development and implementation of a Management Plan (Eichner et al. 2018). Both short and long- term mitigation strategies were incorporated into the Management Plan. Short-term management strategies consisted of alum treatment, which was implemented in May 2021. The alum treatment resulted in improvements in water quality conditions throughout the Pond according to the 2021 Uncle Harvey's Alum Treatment 6-month report completed by SMAST (Eichner & Howes, 2021), but was not a long-term solution. Summer phosphorous levels were reduced by roughly 60% compared to pre-treatment levels. Long term management recommendations include sewering the surrounding residential area. All upgradient parcels contributing phosphorous via wastewater to Uncle Harvey's Pond are included in the Phase 2 Meetinghouse Pond Project which is currently underway.

5.8.2 Pilgrim Lake

The Pilgrim Lake Management Plan was completed in 2019 (Eichner et al. 2019) and indicates that there are high phosphorous and chlorophyll levels as well as anoxic conditions in specific areas of the Lake, with over 75% of the external phosphorus load attributable to septic systems. The Watershed Plan includes a phosphorous reduction strategy that combines short-term treatment and long-term nutrient management strategies. Short-term management strategies include consideration of alum treatment.

Pilgrim Lake experienced a cyanobacteria bloom in summer 2023; as a result, the Town is currently considering an alum treatment similar to Uncle Harvey's Pond. Long-term management of nutrient inputs include sewering of parcels within the Pilgrim Lake watershed, which is planned for Phase 3 Lakes and Ponds. Construction for this phase is planned for 2026 to 2028.

5.8.3 Crystal Lake

The Crystal Lake Management Plan was completed in January 2021 (Eichner et al. 2021) and identifies water quality issues including persistent bottom hypoxia during the summer, and a decreasing trend in water clarity from 2000 to 2016. Crystal Lake experienced a cyanobacteria bloom in summer 2023. The Crystal Lake Management Plan includes alum treatment as a short-term management strategy. Long-term management of nutrient inputs include sewering of parcels within the Crystal Lake watershed, which is planned for Phase 3 Lakes and Ponds. Construction for this phase is planned for 2026 to 2028.

5.8.4 Baker's Pond

The Baker's Pond Management Plan was completed in June 2022 (Eichner et al. 2022) and includes short-term and long-term management strategies similar to those described above. Baker's Pond is outside of the core CWMP area. Management of nutrient inputs is a point of discussion with the Town of Brewster. In the 2010 CWMP Baker's Pond was proposed to have a cluster system with the goal of significantly reducing phosphorus loading there to forestall the degradation that had occurred in other ponds. This option is still under consideration and would require collaboration between Orleans and Brewster.

5.8.5 Cedar Pond

Cedar Pond is not exclusively freshwater, and has fluctuated between freshwater, brackish, periodically tidal, and micro-tidal. Impairment in the waterbody was first addressed in the October 2009 Cedar Pond Technical Memorandum (SMAST, 2009). In July 2013, a Water Quality Management Plan (Eichner et al. 2013) was developed for Cedar Pond. The plan recommended addressing cormorant roosts and reinstallation of flash boards as the two main management strategies. Additionally, priority parcels contributing phosphorous through wastewater to the pond were sewered as part of the Phase 1 Downtown Area construction project.

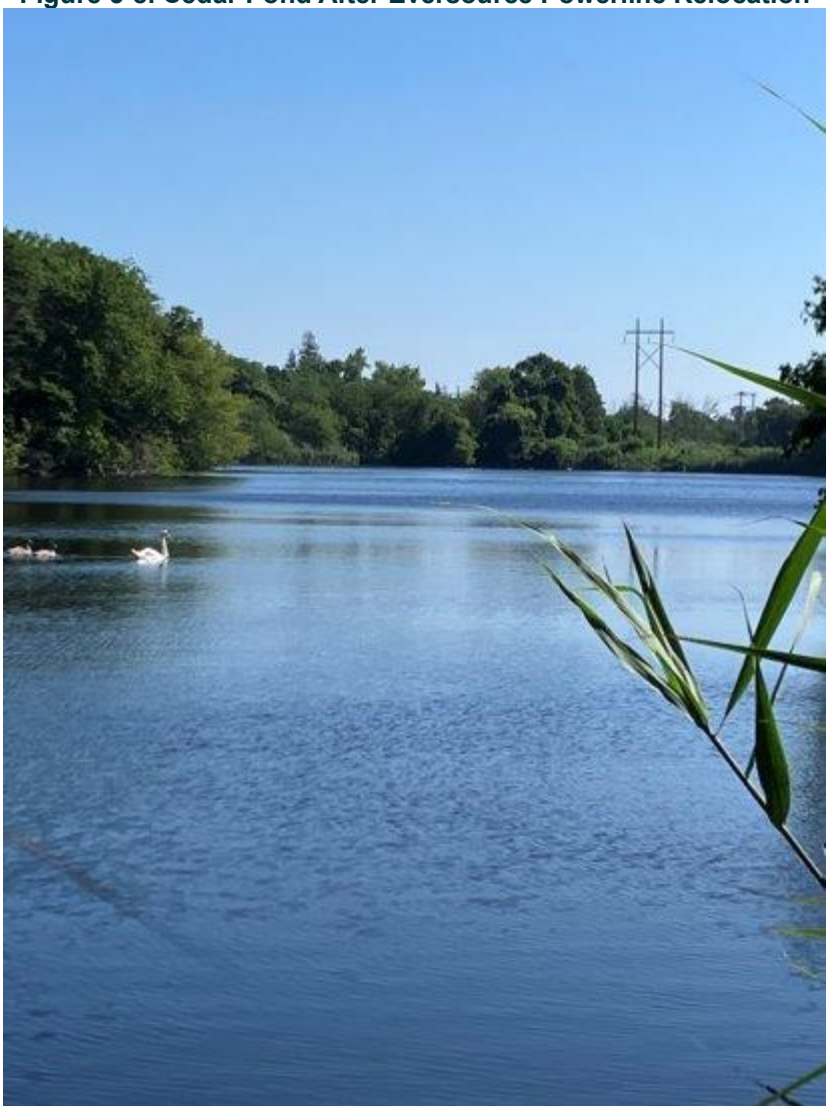
Cormorant roosting on the Eversource power lines above Cedar Pond was well documented and known to be a source of excess nutrients to Cedar Pond. The birds contributed substantial loads of bacteria and nutrients into the Pond, causing severe impairment to water quality and violation of state and federal water quality standards. The Town and Eversource came to an agreement to relocate the power lines. Relocation of the Eversource power lines resulted in a significant reduction of roosting cormorants, and thus related nutrient input into Cedar Pond (**Figure 5-7**and **Figure 5-8**).

For a period of time, the water surface elevation and the effects of the diurnal tidal cycle of Cape Cod Bay on Cedar Pond were controlled by manually adjusted flash boards. Manual flashboards allow for the user to manipulate water levels and flow in a body of water. The boards were located at the interface of Rock Harbor Creek near the mouth of Cedar Pond. This control protocol resulted in decreased tidal flushing and salinity of the Pond compared to conditions that would prevail without the flash boards. The purpose, history, and effects of the flash boards were investigated extensively over several years. In an attempt to increase tidal flushing to improve water quality in the Pond, the boards were removed in 2004, and work to clear debris collected in the outlet control structure occurred through 2007. Reinstallation of the boards was recommended to restore the brackish conditions and improve water quality in Cedar Pond after freshwater pond monitoring began and data was reviewed (SMAST, 2013). In 2018 after MEPA and CCC approval, the boards were reinstalled.

Figure 5-7. Cormorants on Eversource Lines Over Cedar Pond



Figure 5-8. Cedar Pond After Eversource Powerline Relocation



5.8.6 Improved Pesticide and Fertilizer Practices

In addition to the management strategies mentioned above, improved pesticide and fertilizer practices are discussed further below in Section 5.9.

5.9 Stormwater, Fertilizer, and Pesticide Management Programs

5.9.1 Stormwater

The Town has completed a Stormwater Management Plan Update (Town of Orleans, 2022) which outlines compliance with the US EPA/MassDEP 2018 Massachusetts Separate Storm Sewer System (MS4) Permit (Town of Orleans, 2017). A Pleasant Bay Alliance Study (Wright-Pierce, 2023b) documented that the Town's existing MS4 compliance work results in quantifiable reductions in nitrogen loadings to receiving waters. (**Attachment R**) The following activities are included in the 2019 Stormwater Management Plan and annual updates:

- Detailed mapping of the Downtown Area was conducted by SMC Engineering, Inc. to identify all municipal infrastructures with an emphasis on drainage and other utilities. The drainage map and geographic information system data will continue to be updated based on as-built plans, field inspections, and verification conducted by the DPW Field Staff.
- The Town has developed a written Illicit Discharge Detection and Elimination Program Plan that outlines procedures to find, eliminate, and prevent non-stormwater discharges to the MS4. It also identifies the Town staff responsible for the implementation.
- In Permit Year 3 (2021), the Town of Orleans completed outfall screening as outlined in the MS4 Permit and no dry weather flow was recorded.
- The Town has developed a report assessing local regulations to determine the feasibility of making green infrastructure practices allowable.
- The Town has developed a Clean Water Best Practices Manual (Town of Orleans, 2020b) which includes the Town's O&M procedures for parks and open spaces, vehicles and equipment, buildings, and facilities, and MS4 infrastructure.
- The Town reviewed the need to develop and implement Stormwater Pollution Prevention Plans (SWPPPs) at Town-owned or operated facilities and determined that SWPPPs are not needed for these facilities since they do not discharge to the MS4 or a surface water. The facilities have storm drain infrastructure that discharge to subsurface infiltration systems with no off-site discharges for all applicable storm event design criteria.
- The Town was required to identify at least five Town-owned properties that could be modified or retrofitted with Best Management Practices (BMPs) through the reduction of impervious surface.
    - As of 2023, the Town has identified the minimum of 5 Town-owned properties.
    - By Plan Year 5, the Annual Report will identify additional Town-owned sites and infrastructure to which such BMPs are applicable.
- The Town maintains a list of municipally-owned properties that are targeted for modification or retrofits to reduce and treat stormwater discharge through the reduction of impervious surface. These properties will be assessed for the potential to install BMPs. The most recently identified projects are listed in the Town's Capital Improvement Plan.
    - The Town is in the process of drafting a report assessing the Town's existing regulations related to the effect of street and parking lot guidelines on the creation of impervious cover.
    - Best Management Practices Database – the Town began efforts to complete a comprehensive assessment of all stormwater BMPs (approx. 35) in Town to develop an O&M plan.
    - Water Quality Monitoring – water quality monitoring was conducted between May 2015 and May 2016 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 MEP update.
- The above efforts are reviewed on an ongoing basis by the Stormwater Team, which consists of the DPW and Natural Resources Director, DPW Facilities Manager, Town Planner, Health Agent, Conservation Officer, and the Chairperson of the Marine and Freshwater Quality Task Force.

The Phase 1 Downtown Area sewer project has been completed and included updates to the Town's stormwater system and stormwater BMPs. The stormwater management improvements included in Phase 1 are structural stormwater treatment BMPs on Locust Road and Brewster Cross Road. Stormwater management improvements included in the Phase 2 Meetinghouse Pond Area are structural stormwater treatment BMPs on Monument Road (2) and Pond Road. Additional structural BMPs have

been constructed outside of the sewer projects on Doane Road Landing, Champlain Road Landing, Snow Shore Road Landing, and Portanimicut Road Landing that will reduce nutrient loading to receiving waters. Two additional structural BMPs are currently in design to treat stormwater runoff from Herring Brook Way and Cove Road Landing.

5.9.2 Fertilizer, Pesticide, Herbicide 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, herbicides, and pesticides.

The Town developed a Fertilizer Nitrogen Control bylaw that was adopted at the May 13, 2013, Annual Town Meeting; it was amended in its entirety at the October 27, 2014, Special Town Meeting. The purpose of the bylaw is to regulate the use of nitrogen and phosphorous-based fertilizers within the Town, and it includes the following provisions:

- No application of nitrogen between October 16 and April 14 or to impervious surfaces
- No application before or during heavy rain
- No application within 100 feet of Resource Areas protected under the Massachusetts Wetlands Protection Act and Orleans Wetlands Protection By-law
- No application of fertilizer containing phosphorous without a soil test in previous three years indicating that phosphorous is needed for turf growth

Additional steps taken by the Town require a minimum of 35% water insoluble fertilizer and limiting nitrogen fertilizer to ½ pound per sq ft per application applied no more than twice a year, and to limit these applications to between April 15th and October 15th of each year.

As part of the 2019 Stormwater Management Plan, the Town developed a plan to implement an education system. Since the 2019 Plan, the Town has developed and distributed specific messages in educational materials in many forms including: flyers, brochures, pamphlets, and website updates. Brochures regarding proper fertilizer, herbicide, and pesticide use are available at the Town Hall. The educational materials describe steps property owners can take to reduce nitrogen runoff and improve their property with native plants, among other things. Orleans is one of four Massachusetts towns to have such a bylaw (the others are Falmouth, Mashpee, and Nantucket).

The Pleasant Bay Alliance developed a fertilizer and pesticide use policy for municipal properties in April 2012, which the Town of Orleans adopted regarding the use of fertilizer, pesticides, and herbicides on the grounds in or around Town-owned buildings that are under the jurisdiction of the Select Board and Park Commission. The purpose of the policy is to reduce or eliminate nutrient loading from the application of fertilizers and the use of herbicides and pesticides on Town-owned properties by Town employees or private contractors.

The Town recently voted at Special Town Meeting to authorize the Select Board to petition the State for adoption of a new pesticide reduction bylaw. This bylaw would restrict use of pesticides on public and private lands to a limited list of acceptable pesticides. Pesticides, for purposes of this bylaw, include insecticides, herbicides, fungicides, and rodenticides.

5.10 Regional Coordination

On June 8, 2023, the towns of Orleans and Eastham executed a Memorandum of Understanding (MOU) (**Attachment S**). The purpose of the MOU is to continue the process for coordination between the towns in pursing joint Watershed Management Permits through MassDEP. The towns have agreed to work cooperatively to investigate nutrient management solutions for the Rock Harbor and Nauset Harbor Embayment Systems. Both towns will share costs equally and agree to share any information or communications with regulatory agencies. The MOU will remain in effect through the application, review, and issuance of the Watershed Permits, if any are eventually triggered through the designation of either

of these estuaries as Nitrogen Sensitive Areas (NSAs). Currently neither watershed is subject to the 2023 updated Title 5 septic system regulations (310 CMR 15.000: Septic Systems, “Title 5”) and Watershed Permit regulations (314 CMR 21.00: Watershed Permit Regulations) as they have not yet been identified as NSAs.

A small portion of concern pertaining to the Nauset Estuary watershed is located in Brewster. The Town of Orleans is currently evaluating the potential of nitrogen trading options with Brewster regarding nitrogen contributions to shared receiving waters. This approach is identified as a measure in the Pleasant Bay Watershed Permit Targeted Watershed Management Plan. The Town of Orleans is beginning coordination with Brewster, which is just starting their water quality management committee, in addition to being part of the PBA.

There is a possibility of nutrient trading amongst towns within the Pleasant Bay Alliance (PBA) as documented in a 2021 PBA study (Wright-Pierce, 2021; **Attachment T**). The Pleasant Bay Targeted Watershed Management Plan, which is part of the Pleasant Bay Watershed Permit, also identifies the need for Towns to evaluate trading options. The Town of Orleans plans to investigate opportunities to coordinate with Towns within shared-watersheds to explore options for nutrient trading.

5.11 Cluster Systems

The 2010 CWMP recommended five cluster systems, which were intended to provide early protection of certain threatened receiving waters The cluster systems were chosen to incorporate a more focused and rapid removal of nitrogen and phosphorus in certain areas. Four cluster systems were identified to serve neighborhoods that are in the watershed of an impacted coastal embayment and the fifth cluster system was identified to serve the watershed of a freshwater body. The cluster systems would serve approximately fifteen15 to thirty30 properties each and on average remove two-thirds of the nitrogen load required to meet the TMDL. The Town of Orleans is still considering the use of a cluster system at Bakers Pond and Mill Pond and will continue to evaluate the benefits of installing cluster systems in these and potentially other locations as part of its Adaptive Management approach.

6. Project Cost Estimates

MassDEP CWMP guidance requires that a comparative cost effectiveness analysis be performed on all alternatives advanced for detailed evaluation, including present worth or uniform annual cost, capital costs, operation and maintenance (O&M) costs, salvage value, and financing (DEP, 1996). The alternatives that are proposed for detailed analysis in Orleans include traditional wastewater collection and treatment; Permeable Reactive Barriers (PRBs), and aquaculture. Costs for each of these are discussed briefly below.

The 2010 CWMP presented costs for construction of the new WWTF and sewering the "Core Area," which is similar in geographic extent to the sixteen sewer service areas discussed above in Section 3. The capital costs for the Core program, including the new WWTF was estimated using typical unit costs from publicly bid wastewater projects across New England and allowances were added for contingencies, engineering, legal expenses, site investigation costs, and land costs. Construction cost indices were used to adjust the estimate, which was reported as $148.5 in 2008 dollars (2010 CWMP Table 11-7). The 2010 CWMP estimated O&M costs as $1.37 million per year (2010 CWMP Table 11-8); which accounted for some equipment replacement. The 2010 CWMP also included an evaluation of financing measures, including State Revolving Fund low-interest loans and betterment fees.

The Town has completed three sewer collection system projects. For coordination purposes for the Town paving project the Town completed a $3 million project in the Downtown Area. In addition to the project the Town has completed construction of the new WWTF and Downtown Phase 1 Collection System contract. The Downtown Area WWTF contract was completed for approximately $34,000,000. The Downtown Area Collection System contract was completed for approximately $18,000,000. The Phase 2 Meetinghouse Pond Collection System contract, which is underway, is approximately $21,000,000. Phase 2 work includes construction of wastewater collection and conveyance infrastructure, replacing water services, new Baxter Lane and Lucy's Lane water mains, and installing stormwater quality improvements. Costs for future sewer phases are not being provided at this time due to the multitude of factors that may affect future construction bidding. However, the 2010 CWMP estimates combined with the recent actual costs for the WWTF, Downtown Phase 1, and Meetinghouse Pond Phase 2 provide an assessment of the costs for traditional wastewater collection and treatment in compliance with MassDEP CWMP requirements.

A cost analysis of the aquaculture demonstration project at Lonnie's Pond was completed in 2018. The annual costs for the three years of the aquaculture demonstration project in Lonnie's Pond ranged between approximately $250,000 and $450,000, between 2016 and 2018 (AECOM 2018b, **Attachment J**). As discussed above in Section 4.2.1, the Town solicited bids for a contractor to operate the Lonnie's Pond aquaculture project in 2018. Ward Aquafarms was the selected contractor and continues to farm through present day. The Town's costs for aquaculture, which are currently limited to SMAST monitoring costs of approximately $20,000 annually, are expected to decrease in the future once more streamlined monitoring is implemented. Replacement costs if the current operation were to be damaged are expected to be on the order of magnitude of those incurred during the three-year demonstration project.

For PRBs, AECOM estimated the installation cost at $1,230.00 per linear foot (LF) of PRB in 2016 dollars. AECOM has also estimated that annualized replacement cost of $63 per LF and long-term monitoring of $17 per LF, also in 2016 dollars. Replacement costs for media (reactive material used to stimulate bacteria, EVO, repairing/replacing damaged MWs) are assumed to be incurred every fifteen years (AECOM, 2021). AECOM also developed 30-, 60-, and 100-year life cycle cost analyses (LCCA) comparing PRBs with traditional sewer infrastructure (**Attachment M**). The LCCAs addressed implementation costs (e.g., design, bidding, construction) and O&M charges. A 3% inflation rate and then a 1.5% discount rate was included. PRB costs do not include any costs that would be incurred by homeowners (septic system maintenance or upgrades, etc.). These costs include sampling (analytical costs and labor/field equipment), injection costs (including oversight and police detail), and contingencies. Traditional costs include the system components (type of sewer, pumping stations, highway crossings,

etc.), and construction (including oversight and police detail). Additional assumptions and unit costs used in the LCCAs can be found in AECOM's 2021 Memorandum: PRB Full-Scale Watershed Planning (**Attachment M**; AECOM 2021). The LCCA results for Duck Hole, Norseman, Mayflower and Lockwood were included as Table 5 in the 2021 Memorandum and reproduced below in **Table 6-1**, through **Table 6-4**, for each site.

Table 6-1. Duck Hole Road

	30-Year LCCA	**60-Year LCCA**	**100-Year LCCA**	**Length of PRB**
PRB	$11,335,800	$27,203,000	$67,830,500	4,100 ft
Traditional	$13,930,300	$22,394,800	$45,712,100	

Table 6-2. Norseman

	30-Year LCCA	**60-Year LCCA**	**100-Year LCCA**	**Length of PRB**
PRB	$1,999,700	$4,855,300	$11,973,500	580 ft
Traditional	$12,338,300	$16,772,700	$28,160,100	

Table 6-3. Mayflower

	30-Year LCCA	**60-Year LCCA**	**100-Year LCCA**	**Length of PRB**
PRB	$4,969,200	$11,956,900	$29,715,300	1,700 ft
Traditional	$12,765,500	$18,543,100	$33,692,900	

Table 6-4. Lockwood

	30-Year LCCA	**60-Year LCCA**	**100-Year LCCA**	**Length of PRB**
PRB	$7,577,200	$18,219,500	$45,400,700	1,230 ft
Traditional	$19,643,800	$29,703,600	$56,663,500	

The Town is developing a 20-year capital improvement plan that will reflect not only sewer and water quality projects but also many other Town capital needs. The Town must balance the long-term capital costs of wastewater infrastructure with other municipal needs such as the library, fire and rescue station, affordable housing, the community center, the regional high school, and potentially a new elementary school. The Town has developed a phased approach to sewer implementation with a new sewer construction project starting approximately every three years. Each collection system phase is designed to cost approximately $30 million or less in order to take advantage of debt reduction over time.

The Town of Orleans has been able to take advantage of multiple funding sources and subsidies such as the State Revolving Fund (SRF) and the Cape and Islands Water Protection Trust, which has allowed optimization of funding and decreased the financial burden on municipal taxpayers. The Town worked diligently to gain confirmation from MassDEP that their municipal land use policies qualify for 0% SRF loans, which is another advantageous funding source for the Town's wastewater management projects. Once Meetinghouse Pond was approved, the Town of Orleans received a letter stating they were eligible for 0% financing, confirming that land use controls have been designed to deal with the effects of sewering the community. The Town has also established a Wastewater Stabilization Fund dedicated to funding wastewater projects. In May 2019, the Town passed a resolution that directs revenue from hotel/motel and short-term rental fees into the Wastewater Stabilization Fund. To date, the funding in the Wastewater Stabilization Fund has averaged $1.8 million per year, which has provided the Town with a stable funding source to help support the implementation of wastewater projects and subsequent operation and maintenance.

7. Regulatory Review and Coordination

7.1 Response to 2010 CWMP/SEIR, 2018 and 2019 NPC Comments

The Town submitted the CWMP/SEIR to the Massachusetts EOEEA in compliance with MEPA in 2020, and NPCs were submitted in 2018 and 2019. MEPA received several comment letters on all three submittals, which were considered during the evaluation process. Copies of all comment letters received on the SEIR, 2018 NPC, and 2019 NPC and a table summarizing responses are provided in **Attachment D.**

7.2 Cape Cod Commission

The Town of Orleans has coordinated actively with the Cape Cod Commission (CCC) since the preparation of the original CWMP in 2010. A Development of Regional Impact (DRI) is a proposed development that is likely to present development issues significant to more than one municipality in Barnstable County. Projects are referred to the Cape Cod Commission for review. The Cape Cod Commission Act (§12(i)) requires that the Commission review a DRI for any proposed development project for which the Massachusetts Secretary of Energy and Environmental Affairs requires the preparation of an EIR.

At the time of the original 2010 CWMP, the CCC reviewed the Town's proposed wastewater management project as a DRI. The CCC held several hearings to review and discuss the Town's proposed wastewater management project as described in the 2010 CWMP between March and October 2011. On October 13, 2011, the CCC voted unanimously to approve the Town's CWMP and issued a Development of Regional Impact (DRI) with conditions approval (see **Attachment B**). Many of these conditions required communication with the CCC on on-going efforts to design, plan, and implement the CWMP and the amendments described in the current document. As part of the approval, the CCC requested to be involved in the Adaptive Management process that the Town planned to use to implement the CWMP.

The 2011 DRI conditions have been met, as the CCC was an active participant in the Orleans Water Quality Advisory Panel (OWQAP) meetings between 2015 and 2017. In addition, the CCC was a participant at a pre-filing meeting on September 28, 2023, with the Town of Orleans, their consultants, and DEP for a presentation regarding the contents of this Amended CWMP (**Attachment E**). At the pre-filing meeting, the CCC clarified that their procedures for review have changed since the original 2010 CWMP was filed, and that after the MEPA review of the ACWMP NPC is complete, the Orleans Town Manager should send a request for CCC review of the ACWMP for consistency with the approved 208 Plan. The Town will initiate this request immediately after the MEPA approval of the ACWMP NPC is received.

7.3 MassDEP

The Town of Orleans has also been actively coordinating with MassDEP since the 2011 approval of the original CWMP. MassDEP participated in OWQAPs semi-monthly meetings between 2015 and 2017. MassDEP has supported the process to reach a consensus on nitrogen reductions and agreed with the approach summarized in this Amended CWMP. In the September 2023 pre-filing meeting, MassDEP expressed their support for the Town's approach and appreciation of the Town's pro-active efforts to study and plan for nitrogen removals and their benefits to receiving water quality (**Attachment E**). The Town of Orleans will seek MassDEP approval of the final ACWMP. MassDEP has also been actively involved in the development of the Pleasant Bay Watershed Permit and associated annual reports.

7.4 Executive Order 569: Evaluating an Integrated Climate Change Strategy

This ACWMP complies with Executive Order 569, Establishing an Integrated Climate Change Strategy for the Commonwealth (October 16, 2016), regarding climate change and resiliency protocols. This Executive Order aims to ensure that the State Agencies of the Commonwealth will meet greenhouse gas emission reduction limits established by the Global Warming Solution Act of 2008. The Executive Order works to prepare communities for the impacts of climate change. Executive Order 569 resulted in the adoption of the Massachusetts Integrated State Hazard Mitigation and Climate Adaptation Plan (SHMCAP) in 2018 and the MEPA Interim Protocol on Climate Change Adaptation and Resiliency in 2021. The Resilient MA Action Team (RMAT) is an inter-agency steering committee responsible for the implementation, monitoring, and maintenance of the SHMCAP.

Per the MEPA Interim Protocol on Climate Change Adaptation and Resiliency, all projects filing with MEPA after October 1, 2021, are required to submit an output report from the MA Resilience Design Tool to assess the climate risks of the project. Since the CWMP was originally approved in 2011 and subsequent NPCs received MEPA Certificates in 2018 and 2019, the RMAT output is not required to be included as part of the ACWMP and associated NPC filing but has been developed and included as **Attachment U** as requested during a pre-filing MEPA meeting. Similarly, the WWTF was initially approved in 2010, prior to the 2016 EO 569 pertaining to greenhouse gas emissions.

Although the WWTF and associated sewering was approved prior to the enactment of the Executive Orders described above, the Town has endeavored to consider flooding and energy efficiency in the design and construction of phases implemented to date. The WWTF has been constructed on a high point in the municipality, rendering it less vulnerable to future sea level rise, storm surge, and flooding as compared to alternative locations in Town. Energy efficiency was considered as part of the WWTF design and construction, and Cape Light Compact rebates were granted for the project. In addition, energy efficiency will continue to be considered for future phases, such as the inclusion of Variable Frequency Drives (VFDs) for pumps for more energy efficient operation of wastewater conveyance. The Phase 1 Downtown pump station at Stop and Shop considered future flooding and was constructed in 2022 to include flood protection measures above the current FEMA 500-year flood elevation. In future endeavors, the Town will continue to consider the best available data on climate change predictions. Resources available include the data on the resilientMA.org website. Future climate change conditions, as described by the resilientMA.org information repository, will be reviewed and considered to identify appropriate adaptation measures corresponding to the approximate design life of the ACWMP components.

7.5 Section 61 Findings

This section provides an overview of Section 61 Findings which is intended to cover all potential impacts of the project. The Section 61 Findings can be used by any of the involved agencies with permitting responsibilities. The proposed Section 61 Findings have been prepared to comply with the requirements of Massachusetts General Laws, Chapter 30, Section 61, and in accordance with the MEPA regulation 301 CMR 11.07(6)(k). This regulation requires State Agencies and Authorities to review, evaluate, and determine the impacts on the natural environment of all projects or activities requiring permits issued by the State. These Agencies must issue findings describing the environmental impacts and certifying that all feasible measures have been taken to avoid or minimize these impacts.

The previously approved CWMP/SEIR identified measures to avoid damage to the environment or to minimize and mitigate unavoidable environmental impacts, as summarized below. This ACWMP will not involve modification of any previously issued mitigation measures or Section 61 Findings. Mitigation measures that will be employed during the construction period and/or once the facility is operational include:

- Sewer construction on some roads is seasonally restricted
- Segmenting sewer work on public streets to avoid protracted closures
- Designing sewer lines and pump stations to avoid floodplains and to minimize encroachment on the buffers of wetlands and other protected resource areas to the extent practicable
- Restricting work hours on construction sites near residential areas
- Requiring contractors to implement dust control measures
- Erosion and siltation controls at all construction sites
- Complying with all terms of Orders of Conditions for work in wetland buffers
- Installing of odor and noise control systems on operating equipment and facilities
- Implementing of policies that restrict potential odor-generating activities to times of the day with the least impact
- Complying with applicable standards for construction activities near historic structures
- Avoiding, minimizing, and mitigating impacts to habitat of rare and endangered species, including complying with all NHESP conditions
- Selecting wastewater treatment equipment to minimize energy use and maximize nitrogen removal
- Adopting of bylaws and regulations to ensure a "growth neutral" program

Work at Lonnie’s Pond also includes mitigation measures to minimize noise and restrict working hours. Visual impacts were addressed by using black floating mesh bags, removing aquaculture gear annually, minimizing the number of vehicles parked at the boat ramp and limiting vehicles to parking on one side. A narrow diameter telescoping anchor is used to minimize the impacts to the substrate as these occupy much less area than blocks.

8. Public Outreach

The Town held a public presentation of the updated CWMP on November 8, 2023. The main points of the updated plan were presented to those in attendance. The presentation was followed by a question-and-answer session. A second meeting was held on November 30th, 2023, by the Orleans Citizens Forum. This meeting has been videotaped and is available for viewing. This meeting was held in close vicinity to the Town's EJ community to increase accessibility for this population.

The Town also developed an Advance Notification Environmental Justice (EJ) Screening Form (**Attachment V**) for this project which is planned to be submitted to the MEPA provided community-based organizations (CBO) and tribal organization distribution list at least two weeks prior to the submittal of the ACWMP/NPC to MEPA.

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10. Glossary of Terms

Alum Treatment	Alum (aluminum sulfate) is a nontoxic material commonly used in water treatment plants to clarity drinking water. In lakes it is used to reduce the amount of the nutrient, phosphorus, in the water.
Anoxic	A condition in which the aquatic environment does not contain dissolved oxygen.
Aquaculture	The production of aquatic organisms under controlled conditions throughout part or all their lifecycle.
Aquifer	A body of permeable sediment which can contain or transmit groundwater.
Bioactive Nitrogen (BioN)	A bioactive compound is simply a substance that has a biological activity, related to its ability to modulate one or more metabolic processes.
Bottom Hypoxia	Hypoxia refers to the low or depleted oxygen in a water body. It is often associated with the overgrowth of certain species of algae, which can lead to oxygen depletion when they die, sink to the bottom, and decompose.
Build-Out	The total of new development and redevelopment that is projected to occur over a planning horizon, typically 20 years.
Cape Cod Commission (CCC)	Regional land use planning, economic development, and regulatory agency of Barnstable County
Comprehensive Wastewater Management Plan (CWMP)	Current and future wastewater needs are evaluated, wastewater management alternatives are developed. A final plan is chosen through careful comparison and evaluation of the alternatives. The final recommended plan must comply with regulatory requirements and provide for sound wastewater management.
Denitrification	The microbial process of reducing nitrate and nitrite to gaseous forms of nitrogen. It is a response to changes in the oxygen concentration of their immediate environment.
Dissolved Inorganic Nitrogen (DIN)	Comprised of nitrate plus nitrite and ammonium. These forms of nitrogen are readily available to phytoplankton and often control the formation of blooms.
Drainage Swale	An open channel that collects water from hard surfaces and allows it to percolate into the ground, reducing the amount of runoff.
Effluent	Wastewater from sewers or industrial outfalls that flows directly into surface waters.
Embayment	A recess in a coastline forming a bay.
Floating Constructed Wetlands (FCW)	Small artificial platforms that allow aquatic emergent plants to grow in water that is typically too deep for them. Their roots spread through the floating islands and down into the water creating dense columns of roots with lots of surface area.
Gravity Sewers	A network of underground pipes that use gravity to move raw wastewater to a regional wastewater treatment plant.
Groundwater Discharge	When the water in an aquifer reaches a certain saturation level, it can flow out of the ground and into surface water bodies. This can occur naturally or through human activities.
Groundwater Mounding	The localized rise in the groundwater table in response to focused recharge to an aquifer or a vadose zone (the Earth's terrestrial subsurface that extends from the surface to the regional groundwater table) at a rate that exceeds the capacity of the aquifer or the soil to convey these amounts of water away from the recharge zone.

Groundwater Plume	A groundwater plume exists when pollutants or contaminants are present within an aquifer system. The contaminated plume can spread horizontally, vertically, and transversely through the aquifer system by means of infiltration, migration, inter-aquifer exchange, and interaction with surface water.
Kettle Hole	A depression or hole formed by retreating glaciers, from the melting mass of ice trapped in glacial deposits.
Leachate	Any contaminated liquid that is generated from water percolating through a solid waste disposal site, accumulating contaminants, and moving into subsurface areas.
Lithologic	The composition or type of rock
Low-Pressure Sewers	A waste collection and treatment system which is an alternative to conventional gravity collection or septic tank drain field systems. LPS systems utilize a low-pressure pump rather than gravity to transport wastewater through the transmission system.
Massachusetts Environmental Policy Act Office (MEPA)	Conducts reviews of environmental impacts of development projects and other activities that require one or more state agency action.
Massachusetts Estuaries Project (MEP)	MEP was created in 2001 to help determine current nitrogen loads to southeastern Massachusetts estuaries and evaluate reductions that would be necessary to support healthy ecosystems.
Memorandum of Understanding (MOU)	A type of agreement between two or more parties. It expresses a convergence of will between the parties, indicating an intended common line of action.
Monitoring Wells	Principally used for observing groundwater levels and flow conditions, obtaining samples for determining groundwater quality, and for evaluating hydraulic properties of water-bearing strata.
Nitrification	A microbial process by which reduced nitrogen compounds (primarily ammonia) are sequentially oxidized to nitrate and nitrite.
Nitrite vs. Nitrate	Nitrates and nitrites are two different types of soluble compounds. Nitrates (NO_3) consist of one nitrogen atom and three oxygen atoms. Nitrites (NO_2) consist of one nitrogen atom and two oxygen atoms. Both occur naturally in water, soil, and plants. Principal sources of nitrate or nitrite contamination are fertilizers, septic tank waste, livestock manure, and erosion of natural deposits. Since nitrate is highly soluble it is easily transported when contamination sources meet with water. Nitrite is rapidly converted to nitrate in the environment, which means nitrite occurs very rarely in groundwater.
Nitrogen Attenuation	When nitrogen discharges to the upper portions of the watershed, it travels with the groundwater through fresh surface water systems that provide natural nitrogen removal.
Nitrogen Loading	Amount of nitrogen entering an environment.
Nitrogen Reducing Biofilters (NRBs)	Designed to take advantage of naturally occurring soil microbes to achieve significant nitrogen removal by nitrification of influent nitrogen and subsequent denitrification of nitrate.
Nitrogen Removal Credit	Under Title 5, an innovative alternative septic system that achieves an effluent nitrogen concentration of 19 milligrams per liter for a residential property and 25 milligrams per liter for a commercial property may qualify for a Nitrogen Removal Credit. The Credit allows for an increase in design flow per acre in designated Nitrogen Sensitive Areas such as Zone IIs to public water supply wells, in other areas that have formally been designated as Nitrogen Sensitive Areas, and for new construction in areas that have both private wells and on-site septic systems. (From MassDEP)

Notice of Project Change (NPC)	Required to document a material change to a project and any related environmental impacts or to notify the Secretary and reviewers of a lapse of time in the development of a project.
Permeable Reactive Barriers (PRBs)	A wall created below ground to clean up contaminated groundwater. The wall is “permeable,” which means that groundwater can flow through it. Water must flow through the PRB to be treated. The “reactive” materials that make up the wall either trap harmful contaminants or make them less harmful. The treated groundwater flows out the other side of the wall.
Redox	The oxidation-reduction chemical reactions in which the reactants undergo a change in their oxidation states. The term 'redox' is a short form of reduction-oxidation.
Retention Basin	They are used to collect surface runoff and to improve the quality of water by natural processes such as sedimentation, decomposition, solar disinfection, and soil filtration.
Septage Lagoons	A large pond into which the sewage or effluent from the sewage system flows.
Single Environmental Impact Report (SEIR)	MEPA review may result in the issuance of a Certificate with a Scope for a SEIR
SMAST	UMass Dartmouth’s School for Marine Science and Technology
State Revolving Fund (SRF)	A Massachusetts program that helps with the financing of water pollution abatement projects. Two types of funding are provided through this program: the Clean Water and Drinking Water State Revolving Fund grants.
Sub-watershed	A small watershed that nests inside of a larger watershed
The Massachusetts Department of Environmental Protection (MassDEP)	Their mission is to protect and enhance the Commonwealth's natural resources.
Title 5	A Massachusetts state regulation (310 CMR 15.00) governing the siting, construction, inspection, upgrade, and expansion of on-site sewage treatment and disposal systems and the transport and disposal of septage.
Total Maximum Daily Load (TMDL)	A calculation of the highest amount of a pollutant that a water body can take in and still meet standards for healthy systems.
Total Nitrogen (TN)	The sum of all nitrogen forms
U.S. EPA Municipal Separate Storm Sewer System (MS4)	Operate under a National Pollutant Discharge Elimination System (NPDES) MS4 permit. The NPDES MS4 permit requires, permittees to develop and implement a Comprehensive Storm Water Management Program that must include pollution prevention measures, treatment or removal techniques, monitoring, use of legal authority, and other appropriate measures to control the quality of stormwater discharged to storm drains and thence to waters of the United States.
Wastewater Treatment	Chemical, biological, and mechanical processes applied to an industrial or municipal discharge or to any other sources of contaminated water in order to remove, reduce, or neutralize contaminants prior to discharge to a receiving water.
Water Quality	Numerical description of the biological, chemical, and physical conditions of a water body. It is a measure of a water body to support beneficial uses
Watershed	A land area that channels rainfall and snowmelt to creeks, streams, and rivers, and eventually to outflow points such as reservoirs, bays, and the ocean.
Wick Well	A style of groundwater disposal that relies on water infiltrating into the ground via a vertical column of high transmissivity material. Wick wells are utilized in Orleans as an effluent disposal and groundwater recharge method in lieu of spreading infiltration basins.

11. Acronyms

ACEC	Area of Critical Environmental Concern
ACWMP	Amended Comprehensive Wastewater Management Plan
Alum	Aluminum Sulfate
APCC	Association to Preserve Cape Cod
BioN	Bioactive Nitrogen
BMP	Best Management Practice
CBO	Community-Based Organizations
CCC	Cape Cod Commission
CHl-a	Chlorophyll *A*
CWMP	Comprehensive Wastewater Management Plan
DIN	Dissolved Inorganic Nitrogen
DO	Dissolved oxygen
DOC	Dissolved Organic Carbon
DON	Dissolved Organic Nitrogen
DPW	Department of Public Works
DRI	Development of Regional Impact
EIR	Environmental Impact Report
EJ	Environmental Justice
EOEEA	Executive Office of Energy and Environmental Affairs
EVO	Emulsified Vegetable Oil
FCW	Floating Constructed Wetlands
Ft	Foot
FY	Fiscal Year
gpd	Gallons Per Day
GWDP	Groundwater Discharge Permit
I/A	Innovative/Alternative Sewer Systems
Kg	Kilogram
LCCA	Life Cycle Cost Analyses
LF	Linear Foot
LPS	Low Pressure Sewers
LUW	Land Under Water
MassDEP	Massachusetts Department of Environmental Protection
MEP	Massachusetts Estuaries Project
MEPA	Massachusetts Environmental Policy Act
Mg/L	Milligrams Per Liter
MOU	Memorandum of Understanding
MS4	Municipal Separate Storm Sewer System
MW	Monitoring Well

N	Nitrogen
NH_4	Ammonium
NHESP	Natural Heritage and Endangered Species Program
NO_3	Nitrate
NPC	Notice of Project Change
NRB	Nitrogen Reducing Biofilters
NSA	Nitrogen Sensitive Area
NT Technology	Non-Traditional Technologies
O&M	Operation And Maintenance
ORW	Outstanding Resource Water
OWQAP	Orleans Water Quality Advisory Panel
PBA	Pleasant Bay Alliance
PO_4	Phosphate
PON	Particulate Organic Nitrogen
PRB	Permeable Reactive Barriers
RMAT	Resilient Ma Action Team
SEIR	Single Environmental Impact Report
SHMCAP	State Hazard Mitigation and Climate Adaptation Plan
SMAST	School For Marine Science and Technology
sq	Square
SRF	State Revolving Fund
SRP	Soluble Reactive Phosphate
SWPPP	Stormwater Pollution Prevention Plans
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TTSTF	Tri-Town Septage Treatment Facility
TWMP	Targeted Watershed Management Plan
UMass	University of Massachusetts
US EPA	United States Environmental Protection Agency
USDA	United States Department of Agriculture
USGS	United States Geologic Survey
WMAC	Wastewater Management Advisory Committee
WPA	Wetland Protection Act
WWTF	Wastewater Treatment Facility
Yr	Year


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ATTACHMENT A

CERTIFICATES OF THE SECRETARY OF EOEEA (MEPA) ON THE SEIR REPORT FOR THE TOWN OF ORLEANS CWMP AND SUBSEQUENT NPC

The Commonwealth of Massachusetts

Executive Office of Energy and Environmental Affairs
100 Cambridge Street, Suite 900
Boston, MA 02114

Deval L. Patrick
GOVERNOR

Timothy P. Murray
LIEUTENANT GOVERNOR

Richard K. Sullivan, Jr.
SECRETARY

Tel: (617) 626-1000
Fax: (617) 626-1181
http://www.mass.gov/envir

January 28, 2011

CERTIFICATE OF THE SECRETARY OF ENERGY AND ENVIRONMENTAL AFFAIRS
ON THE
SINGLE ENVIRONMENTAL IMPACT REPORT

PROJECT NAME	: Town of Orleans Comprehensive Wastewater Management Plan
PROJECT MUNICIPALITY	: Town of Orleans
PROJECT WATERSHED	: Cape and Islands
EOEA NUMBER	: 14414
PROJECT PROPONENT	: Town of Orleans
DATE NOTICED IN MONITOR	: December 22, 2010

As Secretary of Energy and Environmental Affairs, I hereby determine that the Single Environmental Impact Report (SEIR) submitted on this project **adequately and properly complies** with the Massachusetts Environmental Policy Act (M.G.L. c. 30, ss. 61-62I) and with its implementing regulations (301 CMR 11.00).

The comments I have received on the SEIR from MassDEP, the Cape Cod Commission (CCC) and others indicate that since the Secretary's issuance of the Certificate on the Expanded Environmental Notification Form (EENF), the Town of Orleans (the Town) has worked closely with MassDEP and CCC to provide additional information to address the comments raised on the EENF pertaining to water quality monitoring at the Orleans Wastewater Treatment Facility (Orleans WWTF) site, the Town's Adaptive Management Plan (AMP) and the project's potential impacts to coastal resource areas. I commend the Town on its continued coordination and outreach efforts in this regard. As a consequence of these efforts, MassDEP, CCC, the Pleasant Bay Resource Management Alliance and others have indicated their strong support for the Town's Comprehensive Wastewater Management Plan (CWMP).

I have received a number of comments on the SEIR that express continuing concerns regarding the Town's proposed centralized sewer system design, potential impacts to the

Namskaket Marsh embayment from the groundwater discharge at the Tri-Town site, and the Total Maximum Daily Loads (TMDLs) established for the coastal embayments surrounding the Town of Orleans.

I have fully considered all of the comments received on the EENF and the SEIR and, on balance, I am convinced that the Town has satisfactorily evaluated the project's potential environmental impacts and committed to an appropriate package of mitigation commitments. While I acknowledge the remaining concerns of a number of residents from the Town of Orleans and neighboring Cape Cod communities, I am confident that these concerns can be adequately addressed during the state and local permitting process and through the implementation of the Town's Adaptive Management Plan. Towards that end, I am directing the Town to continue the same high-level of coordination and cooperation with state, regional and local officials that it has shown throughout the MEPA review process for this project as the project proceeds to permitting.

Thus, after careful review of the SEIR and comment letters, and after consultation with MassDEP, the Cape Cod Commission and others, I believe that the SEIR has addressed the substantive issues outlined in the scope and has demonstrated to MEPA's and the permitting agencies' satisfaction that the Town of Orleans has avoided, minimized, and mitigated impacts to the maximum extent feasible. The project may proceed to state permitting where I expect that MassDEP will continue to scrutinize potential project impacts and require additional mitigation where appropriate.

Project Overview

The Orleans CWMP calls for the phased construction of a new centralized municipal sewer system and implementation of non-structural program elements to achieve significant reductions of nitrogen loading and meet TMDL limits for the coastal embayments surrounding the Town of Orleans over a 20-year phased project construction period.

The Town of Orleans' CWMP includes:

- Orleans WWTF

  Constructing a new centralized wastewater treatment and disposal facility to be located at the existing 26-acre Tri-Town Septage Treatment facility site in Orleans capable of achieving effluent concentration limits of 3-5 mg/L for total nitrogen (TN) with an initial designed capacity to treat and dispose up to 0.64 million gallons per day (MGD) of wastewater flows;

- Core Program Sewers

  Constructing approximately 74 miles of new municipal sewer pipe, and approximately 63 sewer pump stations in 6 construction phases to collect and convey approximately 0.64 MGD of wastewater flows from 2,800 individual properties located in the Pleasant Bay, Nauset and Rock Harbor watersheds for treatment and on-site disposal at the Orleans WWTF;

- Non Structural Program Elements

  Implementing non-structural program elements to provide additonal reductions in nutrient loading within the embayments surrounding Orleans including: fertilizer use controls, stormwater management controls, water conservation measures and enhancement of embayment flushing;

- Adaptive Management Plan

  Employing an Adaptive Management Plan that establishes a process for identifying measurable reductions in nitrogen loading; compliance with TMDLs for the coastal embayments surrounding Orleans; and the need for any adjustments or mid-course revisions to the Orleans CWMP prior to constructing the later Core Program phases; and,

- Regional Wastewater Management Opportunities

  The Town's Final CWMP has been designed to also accommodate potential additional future wastewater flows from the neighboring towns of Eastham and/or Brewster (Regional Program).

MEPA Review History

In May 2009, the Town of Orleans (the Town), in accordance with Section 11.05(7) of the MEPA regulations, submitted an EENF with a request that the Secretary allow the Proponent to fulfill its EIR obligations under MEPA with a Single EIR, rather than the usual process of a Draft and Final EIR. The EENF received an extended comment period pursuant to Section 11.06(8) of the MEPA regulations and the Town voluntarily extended the comment period an additional four weeks. The EENF included clear descriptions of the project, a description of the extensive planning and alternatives analysis conducted to date, identified potential environmental impacts associated with the project and provided initial commitments to mitigate impacts. Comments received from MassDEP, the Cape Cod Commission (CCC) and others indicated overwhelming support for the analysis and conclusions included in the EENF and its consistency with legal

requirements. In July 2009, the Secretary issued a Certificate on the EENF and based on a review of the EENF and after consultation with state agencies, determined that the EENF met the regulatory requirements and permitted the Proponent to file a SEIR in fulfillment of Section 11.03 of the MEPA regulations.

State Permits and Jurisdiction

The project is undergoing review pursuant to Sections 11.03(5)(a)(3) and (5)(b)(1) of the MEPA regulations, because the project will likely involve the construction of sewer mains ten or more miles in length and the development of a new wastewater treatment facility with a capacity of more than 1,000,000 gallons per day. The project will require a Groundwater Discharge Permit, a Chapter 91 License, and a 401 Water Quality Certificate from MassDEP. The project must be reviewed by the Natural Heritage Endangered Species Program (NHESP) and the Massachusetts Historical Commission (MHC) because portions of the project occur within Priority Habitat and within or adjacent to recorded archaeological sites and archaeologically sensitive areas, respectively. The project may require a Conservation and Management Permit from NHESP. It may require Federal Consistency Review with the Massachusetts Coastal Zone Management (MCZM) Office. It may also require a Construction Access Permit from the Massachusetts Highway Department. The project may need to obtain a Section 404 Permit from the U.S. Army Corps of Engineers. The project should comply with the National Pollutant Discharge Elimination System (NPDES) General Permit for stormwater discharges from a construction site. It will also require an Order of Conditions from the Orleans Conservation Commission and on appeal only, a Superseding Order of Conditions from MassDEP.

The Town anticipates applying for State Revolving Fund (SRF) loans for subsequent planning and construction of proposed sewer project. Therefore, MEPA jurisdiction is broad and extends to all aspects of the project that may cause Damage to the Environment, as defined in the MEPA regulations.

REVIEW OF THE SINGLE ENVIRONMENTAL IMAPCT REPORT and FINAL CWMP

Project Description

The SEIR includes a detailed discussion of the findings of the Massachusetts Estuaries Project (MEP) Technical Reports and/or TMDLs established for Pleasant Bay, Rock Harbor, Namskaket and Little Namskaket embayments used by the Town in the design of the Orleans

CWMP. The SEIR provides additional information to satisfactorily demonstrate that the Tri-Town site is an acceptable effluent recharge site that could accommodate the treatment and on-site discharge of the Core Program's estimated wastewater flows. The SEIR provides a detailed description of the Town's proposed Adaptive Management Plan and its water quality monitoring program for the Tri-Town site and the coastal embayments surrounding the Town of Orleans. The SEIR identifies significant environmental benefits and impacts, and measures that will be taken to avoid, minimize and mitigate the Core Program sewer project's unavoidable impacts to environmental resource areas. The SEIR includes a proposed schedule for completing the final design and environmental permitting for the Orleans CWMP and each phase of its sewer construction program. The SEIR includes additional information and maps identifying the areas in Orleans where construction of new sewers or cluster systems are proposed and the locations where sewer lines, pumping stations, and other facilities will be located.

Structural Program Elements

Core Sewer Program

The Town's core sewer construction plan (Core Program) involves the phased construction of new sewers to eliminate septic systems in areas of Orleans having the greatest need for nitrogen control and located upgradient of nitrogen sensitive watersheds and major freshwater ponds. As described in the SEIR, the Core program's sewer service area was designed to provide for the collection of as much wastewater nitrogen as necessary using the least amount of wastewater collection and conveyance infrastructure.

The Core Program includes the construction of a new centralized wastewater treatment facility (Orleans WWTF) to be located at the existing 26-acre Tri-Town Septage Treatment facility located near the intersection of Route 6 and Route 6A at 29 Overland Way in Orleans. The new Orleans WWTF is designed with an initial capacity to treat and dispose up to 0.64 MGD and will employ a 4-stage Bardenpho nitrogen removal process that will provide treatment levels capable of achieving nitrogen effluent concentrations of 3-5 milligrams per liter (mg/l) of total effluent Nitrogen (Level 2 nitrogen limits) and the removal of numerous pathogenic organisms. Under the Core Program, a total of approximately 74 miles of new municipal sewer pipe, and approximately 63 sewer pump stations will be constructed in 6 construction phases to collect and convey 2030 design year wastewater flows (approximately 0.64 MGD) from 2,800 individual properties (approximately 53% percent of the Town) located in the Pleasant Bay, Nauset and Rock Harbor watersheds for treatment and on-site disposal at the Orleans WWTF site. Construction of Phase 1 of the Core Program is expected to be completed in 2017 and will include the construction of the new Orleans WWTF (to operate at 50% design capacity) and approximately 15 miles of new sewers and 7 pump stations located primarily throughout the downtown area of Orleans.

Phase II of the Core Program will include the construction of approximately 11 miles of sewers and 10 pump stations. Phase 2 will also involve the construction of five separate below-ground cluster wastewater treatment systems with approximately 11 miles of additional gravity sewers and new pump stations to serve neighborhoods located in the watersheds of four impacted coastal embayments and one freshwater pond including the headwaters of the Paw Wah Pond, Lonnies Pond, Arey's Pond, Mill Pond and Baker's Pond, respectively. As described in the SEIR, these cluster systems will provide interim nitrogen and phosphorous removal to these impacted surface water bodies in the early phases (Phases 1 and 2) of Core Program construction and many years in advance of the construction of the later phases of Core Program construction for these areas of Orleans. The Town proposes to eventually convert and incorporate these cluster wastewater treatment systems to serve as pump stations for the Core Program municipal sewer system. The Town anticipates that the Phase 2 sewer construction work will be completed in 2020. Construction of the remaining Core Program phases (Phases 3-6) is anticipated to be completed in 2032.

Septage Handling Facility

The Orleans WWTF will include facilities for a new septage receiving and handling station to replace the existing Tri-Town Septage Treatment Facility and will be designed to receive, treat and dispose of truck-transported septage from non-sewered areas in Orleans together with septage from the other Tri-Town District communities of Brewster and Eastham.

Sludge Handling Facility

The Orleans WWTF will also include new facilities for preparing remaining sludge materials resulting from the wastewater treatment and septage handling processes for off-site trucking for suitable reuse and disposal.

Non Structural Program Elements

The Orleans CWMP also calls for the implementation of a number of cost-effective non-structural elements designed to provide measurable reductions in nitrogen loading to the embayments surrounding Orleans such as fertilizer management, stormwater management, enhanced embayment flushing and land use controls.

According to the information provided in the SEIR, fertilizer use and stormwater runoff can contribute up to 7% and 8% of watershed nitrogen load to coastal embayments in Orleans, respectively. The Town has committed to implement fertilizer use controls to reduce the use of fertilizer products on lawns, gardens and agricultural areas in Orleans. The Town has also committed to adopting stormwater management regulations to reduce nutrient loading from surface runoff to embayments surrounding Orleans, and to pilot the potential use of enhanced

embayment flushing to increase the assimilative capacity of coastal embayments to reduce nitrogen loading by increasing their flushing rates. MassDEP has indicated that some of these non-structural program elements may hold promise for reducing nutrient loading to coastal embayments but will require an extensive evaluation by MassDEP to determine if an acceptable nitrogen reduction credit can be applied in the Orleans CWMP.

Water Quality and Wastewater Treatment

Marine Embayments

The SEIR includes a detailed discussion of the findings of the MEP Technical Reports and/or TMDLs established for Pleasant Bay, Rock Harbor, Namskaket and Little Namskaket embayments used by the Town in the design of the Final Orleans CWMP. The Town has continued to participate in MEP's efforts to conduct water quality sampling and identify nutrient loading problems for the Town's coastal embayments. The Technical Reports produced by the MEP are used by MassDEP and the US Environmental Protection Agency (EPA) to establish Total Maximum Daily Loads (TMDLs) for nitrogen loading to these coastal emabyments and their tributaries. The MEP has provided Technical Reports for Pleasant Bay and the Northside Cape Cod Bay embayments of Rock Harbor, Namskaket and Little Namskaket Creek. The final MEP Technical Report for Nauset Marsh has been delayed. MassDEP and EPA have established TMDLs for Pleasant Bay and its coastal tributaries.

The TMDLs for the Northside Cape Cod Bay embayments has not yet been released. As described in the SEIR and the comments received from CCC, the Town incorporated information from the draft MEP Technical Report findings for Nauset Marsh in the Town's final design of the Orleans CWMP. Specifically, the Orleans CWMP includes a conservative target percentage (55%) nitrogen removal for Nauset Marsh. CCC supports the Town's interim use of this nitrogen removal estimate for Nauset Marsh. According to the comments received from MassDEP and CCC, the estimated nitrogen loading reductions resulting from the Town's phased construction of the Core Program are consistent with published or expected TMDLs for the watersheds and embayments surrounding the Town of Orleans. As a condition of its approval of the Orleans CWMP project, CCC will require the Town to review the final MEP Report for Nauset Marsh when it becomes available to determine what if any revisions to the Orleans CWMP may be needed to address nutrient loading and water quality issues affecting the Nauset Marsh/Town Cove embayment.

MassDEP and CCC have requested that the Town provide confirmatory modeling results using the Linked Water Quality Model to identify estimated reductions in nitrogen loading and interim water quality improvements associated with each phase of the Town's Core Program sewer construction program. The Town will be required to complete the confirmatory modeling

for the Orleans CWMP as a condition of MassDEP's Groundwater Discharge Permit and CCC's Development of Regional Impact (DRI) approval process. MassDEP's comments on the SEIR identified the need for additional water quality modeling at the Little Naskaket Marsh and renewed monitoring and characterization of the Tri-Town plume. According to MassDEP comments, the wastewater plume from the Tri-Town site was last monitored in 2001 by the USGS and determined to be moving in a northwesterly direction. MassDEP has indicated that the Town will be required to fully characterize the plume's direction and extend of its leading edge as part of the Town's ongoing water quality monitoring program responsibilities. Studies of the Tri-Town wastewater plume and their findings will be made part of the Adaptive Management Plan and included in the Town's annual TMDL Compliance Report described below.

Freshwater Ponds

As described in the SEIR, Phase 2 work will include the construction of five separate below-ground cluster wastewater treatment systems with approximately 11 miles of additional gravity sewers and pump stations to serve neighborhoods located in the headwaters of the watersheds for four impacted coastal embayments and one freshwater pond including Paw Wah Pond, Lonnies Pond, Arey's Pond, Mill Pond and Baker's Pond, respectively. Each of the five cluster wastewater treatment systems will have a design capacity to accommodate approximately 10,000 – 20,000 gpd of wastewater flow (15 – 30 properties) to achieve an effluent nitrogen concentration of 5- 8 mg/L. These cluster systems will provide interim nitrogen and phosphorous removal to these impacted surface water bodies in the early phases (Phases 1 and 2) of Core Program construction and many years in advance of the construction of the later Core Program sewer phases in these areas of Orleans. The Town proposes to eventually convert and incorporate these cluster wastewater treatment systems to serve as pump stations for the Core Program municipal sewer system. The Phase 2 sewer construction work is expected to be completed in 2018. Construction of the remaining Core Program phases (Phases 3-6) is anticipated to be completed by 2030.

In comments previously submitted on the EENF, CCC recommended that the Town consider constructing an interim cluster wastewater collection and treatment system to serve the neighborhoods located in the headwaters of for Cedar Pond area as part of the Town's Phase 1 Core Program work. According to the information provided in the SEIR, factors contributing to the impairment of Cedar Pond have not yet been adequately identified. The Town has committed to review the forthcoming amended MEP Report for Rock Harbor when it becomes available to re-evaluate the need for constructing a cluster sewer system to serve the Cedar Pond neighborhoods.

Orleans Wastewater Treatment Facility

The proposed Orleans WWTF will have an initial design capacity of 0.64 MGD and will employ a 4-stage Bardenpho nitrogen removal process that will achieve nitrogen effluent concentrations of 3-5 milligrams per liter (mg/l) of total effluent Nitrogen. Treated wastewater effluent will be discharged to 10 rapid infiltration beds. The Town completed a review of existing hydrogeological studies, hydraulic load testing and other groundwater modeling analyses and determined that the Tri-Town site has an effluent disposal capacity (approximately 1.78 mgd) to accommodate the Core Program's wastewater flows. As discussed below, the Orleans WWTF is designed with reserve treatment capacity to accommodate the treatment of potential future additional wastewater flows anticipated from sewering the entire Town of Orleans under the Town's Expanded Program design. Acoording to the information provided in the SEIR, under the Extended Program, a total of 1.14 MGD of wastewater flow will be collected from 5,300 individual properties for treatment at the Orleans WWTF. According to the Town, construction of the Extended Program would require an additional 15-20 years from the completion of the Core Program sewer construction work.

The treatment and on-site disposal of the Core Program's wastewater flows will utilize approximately 60% of the infiltration system's capacity. The disposal of treated effluent under the Regional Program would utilize approximately 90% of the infiltration system's discharge capacity. The disposal of treated effluent under the Town's Extended Program would exceed the infiltration system's capacity and require one or more additional off-site groundwater disposal sites or water reuse options.

As described in the SEIR, approximately 67% of the treated wastewater effluent from the Tri-Town site will discharge to Namskaket Marsh, 9% will discharge to Little Namskaket Marsh and approximately 25% will discharge to Cape Cod Bay. The MEP Reports for the Namskaket and Little Namskaket Marsh systems indicate that these embayments have adequate assimilative capacity to prevent nitrogen overloading from the discharge of the Core Program's treated wastewater flows. The Town has concluded that the disposal of treated effluent from the Orleans WWTF will not impact local groundwater and surface water resources including existing water table mound heights and nutrient loading to both the Namskaket Marsh and Little Namskaket Marsh. The Town has committed to monitor groundwater resources around the periphery and down gradient of the Orleans WWTF site to identify any impacts on groundwater resources and coastal embayments surrounding the Town of Orleans. According to the comments received from MassDEP, this groundwater monitoring commitment will be incorporated into MassDEP's Groundwater Discharge Permit for the Orleans WWTF. CCC has indicated that the Town will be required to conduct groundwater monitoring of the Tri-Town site as part of the Town's Adaptive Management Plan as a condition of CCC's DRI approval process.

Adaptive Management Plan (AMP)

The Orleans CWMP contains an AMP that identifies a systematic process for determining the effectiveness of the early phases of Core Program construction and the need for any revisions to the Orleans CWMP before initiating later Core Program construction phases. The AMP includes a Groundwater and Surface Water Quality Monitoring Plan that identifies specific annual water quality monitoring activities to be completed by the Town for the Tri-Town Site area, sensitive coastal embayments and select freshwater ponds in Orleans. The AMP requires the Town to coordinate its ongoing water quality monitoring activities with MassDEP, CCC, and the ongoing water quality monitoring and modeling activities in Orleans being carried out by MEP, the United States Geological Survey (USGS), the Pleasant Bay Alliance, the Orleans Ponds Coalition and the Orleans Marine and Fresh Water Quality Task Force.

The AMP also requires the Town to prepare an annual TMDL Compliance Report to document the reductions in watershed nitrogen loads achieved from the Town's phased sewer construction program. MassDEP will review the TMDL Compliance Report to determine the Town's compliance with the established TDMLs included in the Orleans CWMP. The TMDL Compliance Report will also be used to identify the need to make any adjustments or mid-course corrections to the Orleans CWMP prior to initiating the next phase of project construction. The annual TMDL Compliance Report will be distributed to MassDEP, CCC, MEP, local area watershed associations and representatives from neighboring towns.

Comments received from the Sierra Club, Clean Water Action and others have requested that the Orleans CWMP incorporate a monitoring program to identify the presence of contaminants of emerging concern (CECs) in wastewater flows and effluent discharges at the Orleans WWTF. According to MassDEP, no regulations or policies are in place to govern the monitoring or treatment of CECs at WWTFs as this issue is currently being studied by MassDEP, the US Environmental Protection Agency (EPA) and others. MassDEP has indicated that when such CEC policies and regulations are established, they could be included in the Town's AMP for the Orleans CWMP. I ask that the Town work closely with MassDEP to ensure that the final design of the Orleans WWTF may be modified in the future to accommodate potential future opportunities for CEC monitoring and treatment.

Wetlands and Waterways

Most of Orleans' proposed Core Program sewer construction project is located within existing roadway right-of-ways. According to the information provided in the SEIR, the Town's sewer project will not directly impact BVW resources. The Town has indicated that the Core Program sewer line routes and/or pumping station locations may encroach in the 100-foot buffers

of regulated wetland resource areas and result in impacts to wetland buffer zone area. Prior to construction of projects within the resource area buffer zones, the Town will apply for wetlands related permits, in accordance with MassDEP and the Orleans Conservation Commission regulations. I anticipate that the Town will continue to examine alternatives that avoid impacts to wetland resource areas, their associated buffer zones, riverfront protection areas, and 100-year flood plain areas during permit review.

According to the SEIR, the Core program construction activities will not be located within tidelands and will not require a Chapter 91 License from MassDEP. The project may be revised as it advances to final design and permitting. In the event the project undergoes further revisions that result in the alterations to tidelands, the Town will need to contact the MEPA Office to determine if further MEPA review is required to address impacts to waterways and tidelands and if a Public Benefits Determination will be required.

Rare Species

As described in the SEIR, the Tri-Town Septage Treatment Facility site, is located within Priority Habitat for the Eastern Box Turtle (*Terrapene carolina*), the Diamond-backed Terrapin (*Malaclemys terrapin*), Salt Reedgrass (*Spartina cynosuroides*) and Mitchell's Sedge (*Carex mitchelliana*). According to NHESP's previous comments on the EENF, the construction of the Orleans WWTF will occur within mapped habitat for the Eastern Box Turtle (Terrapene carolina). The Town, in consultation with NHESP, completed an evaluation of alternative site layouts for the Orleans WWTF facility. The SEIR includes a detailed description of the Town's revised site layout for the Orleans WWTF that locates the facility's rapid infiltration beds to the northern most portion of the site and maximize the reuse of existing disturbed areas and septage facility infrastructure for wastewater treatment. According to the Town, the revised site layout will result in the permanent alteration of approximately 4.9 acres of on-site habitat and will avoid fragmentation of undisturbed habitat areas within the proposed Orleans WWTF site to avoid a 'take' of the Eastern Box Turtle. NHESP's comments on the SEIR indicate that the construction of the Orleans WWTF will create temporary disturbances from site grading and may result in more than 5 acres of impact to mapped habitat for the Eastern Box Turtle. NHESP anticipates that the Town may be able to further reduce the projects temporary impacts to habitat by revising the project's proposed site grading and re-vegetation plans.

I ask that the Town continue to work closely with NHESP and consult with the Orleans Conservation Commission during the final CWMP project design and for each phase of Core Program construction to identify necessary construction and post-construction conditions and commitments to avoid adverse impacts to resource area habitats for state-listed species that may be located within and adjacent to the Orleans WWTF site, the five local cluster system project sites and the Core program sewer collection area.

Historical/Archeological Resources

As described in the SEIR, portions of the Core Program's sewer construction work are located within the Old King's Highway Regional Historical District (OKHRHD). The Town has committed to design and construct above ground sewer pump stations located within the OKHRHD with appropriate architectural features consistent with OKHRHD standards. According to the Town, the proposed cluster wastewater treatment systems may also be located within or adjacent to areas where archaeological resources may be present. The Town has committed to complete a reconnaissance archeological survey for each of these cluster site locations. MHC recommends that the Town submit to MHC for review and comment detailed project plans for Core Program construction phase as they may become available. Detailed project plans for Core Program construction phase should also be submitted to the OKHRHD for review and comment I ask that the Town continue to work closely with MHC during final project design and prior to each successive sewer construction phase to identify opportunities to avoid, minimize and mitigate project construction impacts to historic and archeological resources in the project area.

Greenhouse Gas Emissions (GHG)

The project requires an EIR and therefore is subject to the requirements of the MEPA Greenhouse Gas Emissions Policy and Protocol ("the Policy"): http://www.mass.gov/envir/mepa/downloads/GHGPolicyRev1108.pdf . The policy requires project proponents to quantify the direct and indirect CO_2 emissions from the proposed project, including CO_2 emissions associated with the buildings & plant operations, and to compare those emissions to a project baseline, which includes no-build conditions as well as an assessment of the emissions associated with the current effective building code ("base case").

In this instance, the Town consulted with MassDEP, DOER and EPA and developed a "base case WWTF" using GHG emissions data obtained from EPA's Energy Star Portfolio Manager database for comparable WWTFs having similarly sized treatment capacities, wastewater nutrient loads and seasonal demand fluctuations. The Town's estimated GHG emissions for the Base Case WWTF is approximately 900 tons of carbon dioxide per year (CO_2/yr). The SEIR presented an evaluation of 20 GHG reduction mitigation measures associated with wastewater treatment processing, building systems and facility operation and management. The Town has committed to incorporate a number of GHG reduction measures related to Building and Process systems for the Orleans WWTF that will result in a reduction of approximately 64 tons CO_2/yr from the Base Case WWTF, a reduction of approximately 6 percent. Comments received from the Department of Energy Resources (DOER) indicate that even greater reductions may be achieved by through the use of alternative nitrogen demand technology. I encourage the Town to

consider DOER's comments. The Town also identified 11 additional GHG reduction measures including the use of on-site renewable energy (solar photovoltaic (PV), Wind Turbine) that the Town has committed to further explore during final design of the Orleans WWTF. As described in the SEIR, these 11 additional GHG reduction measures could result in a reduction of approximately 309 tons CO_2/yr (34.3%) from the Base Case WWTF. The Town should commit to continue to work closely with MassDEP and DOER during final WWTF design and permitting to identify and incorporate appropriate energy efficiency measures into the buildings, treatment processes and operations for the Orleans WWTF. MassDEP has indicated that it will work with the Town to incorporate these GHG reduction measures through its project financing and permitting authority. Upon completion of the construction of the Orleans WWTF, the Town should provide a certification to the MEPA Office signed by an appropriate professional (e.g., engineer, architect, general contractor) indicating that the all of the GHG mitigation measures committed to by the Town as described in the SEIR and this section of the Certificate that collectively will reduce Building and Process systems GHG Emissions for the proposed project by at least 6 percent have been incorporated into the Orleans WWTF project. This certification should be supported by as-built plans. For those measures that are operational in nature (i.e. TDM, recycling) the Town should provide an updated plan identifying the measures, the schedule for implementation and how progress towards achieving the measures will be obtained. MassDEP should incorporate this self-certification requirement into its Section 61 finding for this project.

Sewering and Growth Management

The SEIR includes a discussion of potential land use control mechanisms to limit unwanted secondary growth related to the construction of the Town's Core Program sewer project. The Orleans Board of Health adopted its Nutrient Management Regulation in 2008 restricting wastewater flow to 110 gpd per 10,000 sf of lot area for new development or expansion of existing development. The Town is proposing to implement a 'flow-neutral' Sewer Use Regulation to be administered through the Orleans Board of Health, which would limit the redevelopment of existing properties by restricting the amount of additional wastewater flow/nitrogen load from the redeveloped property to the amount of wastewater flow from the property to what is allowed under Title 5 and local zoning. The Town is also proposing to adopt Section 1A of the Chapter 83 of the Massachusetts General Laws to enable the Town to implement a "checkerboard" sewer connection bylaw that will allow the Town to select specific lots that will be connected to the municipal sewer system and lots that do not need sewering and therefore will not be allowed to connect to the new sewer system. Lastly, the Town is also considering implementing an accelerated program of open space acquisition in nitrogen-sensitive watersheds to avoid the potential nitrogen loads from the future development of these currently undeveloped properties. The Town should adopt and implement any proposed growth by-laws, regulations, and policies prior to the construction of any new sewers.

Costs to Homeowners

As described in the SEIR/Final CWMP, the Core Program will be constructed in six phases over 15-20 years and will have an estimated capitol cost of approximately $150,000,000. The estimated operation and maintenance (O&M) costs for the Core Program total approximately $1.4 million dollars. According to the Town, construction of the Expanded Program to extend the new centralized sewer system to the remaining properties located outside of the Core program area will cost an additional $96,000,000 in capital costs. The Town proposes to recover 80% of the project's municipal debt service through user and non-user property taxation and 20% through betterment assessments to be paid by users of the sewer system. The SEIR provides average cost estimates (capital and O&M) for households connected to the Core Program sewer system ($2,592.00) and those households not connected to the Core Program sewer system ($2,544.00). According to the information provided in the SEIR, the proposed Core Program of new sewer construction may qualify for available state and/or federal loan and grant assistance including the State Revolving Fund (SRF) and the US Department of Agriculture's Rural Development Grant program thereby reducing the average cost estimates (capital and O&M) for households connected to the Core Program sewer system from $2,592.00 to $1,692.00 and those households not connected to the Core Program sewer system from $2,544.00 to $1,965.00.

Future Sewer Expansion

The Town's Core Program sewer collection system has been designed to accommodate larger wastewater flows associated with the potential future expansion of new sewers to the entire Town of Orleans (Expanded Program) and/or additional wastewater flows from the neighboring towns of Eastham and Brewster (Regional Program).

Expanded Program

Under the Expanded Program, new sewers would be extended to all of the Town of Orleans and would result in the collection and conveyance of a total of 1.14 MGD of wastewater from 5,300 individual properties for treatment at the Orleans WWTF. As mentioned elsewhere in this Certificate, additional wastewater disposal sites and/or treated effluent reuse options may be required to accommodate the disposal of the Expanded Program wastewater flows.

Regional Program

The SEIR includes a detailed discussion of potential regional approaches to address the wastewater treatment and disposal needs for the Towns of Orleans, Eastham and Brewster, and the regional issues pertaining to nutrient loading, wastewater treatment and disposal affecting the Nauset Marsh/Town Cove and Pleasant Bay coastal embayments.

According to the comments received from the Town of Eastham, Eastham recently completed its wastewater planning study and identified as its preferred alternative a regional wastewater treatment option with the Town of Orleans involving the conveyance of a portion of Eastham's wastewater flows from the Nauset/Town Cove/Rock Harbor Watersheds to the Orleans WWTF for treatment and disposal. The Town of Eastham has expressed an interest in working with the Town of Orleans to identify opportunities for constructing its sewer connection to the Orleans WWTF in the early phases of Orleans' Core Program construction.

The SEIR indentifies a number of options for a regional wastewater treatment approach with the Town of Brewster including the conveyance of a portion of Brewster's wastewater flows from the Pleasant Bay Watershed to the Orleans WWTF for treatment and disposal and/or locating a new satellite WWTF in the Town of Brewster to treat a portion of Orleans' and Brewster' wastewater flows from the Pleasant Bay Watershed. As described in the comments received from the Town of Brewster on the SEIR, Brewster has recently initiated efforts to complete an Integrated Water Resources Management Plan. As part of its planning process, the Town of Brewster has expressed a desire to continue to work with the Town of Orleans, MassDEP and others to address regional water and wastewater management issues affecting their shared watersheds and coastal embayments.

I ask the Towns of Orleans, Eastham and Brewster work closely together with MassDEP and CCC and others including the Pleasant Bay Resource Management Alliance and the Cape Cod Water Protection Collaborative to continue the discussion of possible opportunities to integrate the Town of Orleans' wastewater treatment planning efforts with the water and wastewater management planning efforts being undertaken by the Towns of Eastham and Brewster.

Construction Impacts

The construction period will be the major source of impacts from the project, including impacts from earth moving, impacts to vegetation, potential impacts from erosion and sedimentation, traffic impacts on adjacent roadways, and impacts to adjacent land uses. Construction period impacts and mitigation measures have been described in the SEIR, including impacts from noise and dust, impacts on trees and other vegetation, and traffic impacts. This section of the SEIR includes a discussion of measures that will be taken by the Town to minimize and mitigate construction period impacts (in particular impacts on sensitive receptors or exceptional resources). Given the availability of Ultra Low Sulfur Diesel (ULSD) fuel and the requirements for off-road engines in 2010, the construction equipment for the project should operate on ULSD fuel to reduce emissions of fine particulate matter. The Town should consult with MassDEP to discuss additional construction period diesel mitigation measures. I strongly encourage the Town to commit to using lower emission equipment in addition to requiring its contractors to retrofit diesel-powered equipment with emissions controls, such as particulate filters or traps, and use low-sulfur diesel fuel. The Town should require its contractors to use

On-Road Low Sulfur Diesel (LSD) fuel in their off-road construction equipment which can increase the removal of particulate matter (PM) by approximately 25% beyond that which can be removed by retrofitting diesel-powered equipment. All construction-related refueling and equipment maintenance activities should be conducted under cover on impervious surface areas with containment, and outside of any wetlands resource areas, endangered species habitat areas, residential areas and wellhead protection areas.

The Town should develop and enforce a spills contingency plan to address potential releases of oil and/or hazardous materials from pre and post construction activities as recommended by MassDEP. To the extent feasible, existing access routes within the ROW will be used for construction access. In areas where access roads do not exist, the Proponent will construct temporary access roads along existing land contours to minimize grading requirements for construction vehicle access. Best Management Practices (BMPs) that will be implemented during construction include the use of swamp mats and erosion control barriers, and a Stormwater Pollution Prevention Plan.

Mitigation and Section 61 Findings

The SEIR includes a separate chapter on mitigation measures and proposed Section 61 Findings for all state permits and approvals required for the project. This section of the SEIR provides a description of the Town's proposed mitigation plan, and discusses the value of the proposed mitigation in terms of the resources it provides and the opportunities for open space protection, and active and/or passive recreation it affords. Final Section 61 Findings will be prepared by state agencies issuing permits for this project and will include conditions considered binding upon the Proponent as mitigation commitments. State agencies and the Town should forward final copies of Section 61 Findings to the MEPA Office for the project file and for notice in the Environmental Monitor. I ask the Town to continue to work closely with MassDEP, CCC and the Pleasant Bay Resource Management Alliance to design and implement a sustainable Comprehensive Wastewater Facilities Plan and mitigation plan for the Town of Orleans that will help to offset the proposed project's municipal sewering impacts.

Conclusion

After a thorough consideration of the comments received from MassDEP and others, I am satisfied that any outstanding design issues relating to sewer layout and construction phasing will be fully considered and addressed during state and local permitting. As noted elsewhere in this Certificate, the Town should continue to work closely with MassDEP, NHESP and MHC during final project design.

January 28, 2011
DATE

Richard K. Sullivan, Jr., Secretary

Comments received:

01/19/11 Division of Marine Resources (DMF)
01/19/11 Pleasant bay Resource Management Alliance
01/19/11 Town of Brewster
01/19/11 Mary Hartley
01/20/11 Cape Cod Commission (CCC)
01/20/11 David Farquhar
01/20/11 Department of Energy Resources (DOER)
01/20/11 Kevin H. Cassidy
01/20/11 Beverly M. Carney
01/21/11 MA Department of Environmental Protection (MassDEP) – SERO
01/21/11 Sierra Club, Cape Cod and the Islands
01/21/11 Alan McClennen, Jr. FAICP
01/21/11 Beverly M. Carney
01/21/11 Ben A. Buck
01/21/11 Clean Water Action
01/21/11 Brian and Judy Embleton
01/21/11 Victoria L. Reis
12/22/11 Massachusetts Historical Commission (MHC)
01/25/11 Town of Eastham
01/27/11 Natural Heritage & Endangered Species Program (NHESP)

SEIR #14414
RKS, Jr./NZ/nz

The Commonwealth of Massachusetts
Executive Office of Energy and Environmental Affairs
100 Cambridge Street, Suite 900
Boston, MA 02114

Charles D. Baker
GOVERNOR

Karyn E. Polito
LIEUTENANT GOVERNOR

Matthew A. Beaton
SECRETARY

Tel: (617) 626-1000
Fax: (617) 626-1081
http://www.mass.gov/eea

December 7, 2018

CERTIFICATE OF THE SECRETARY OF ENERGY AND ENVIRONMENTAL AFFAIRS
ON THE
NOTICE OF PROJECT CHANGE

PROJECT NAME	: Town of Orleans Comprehensive Wastewater Management Plan – Effluent Discharge Location
PROJECT MUNICIPALITY	: Orleans
PROJECT WATERSHED	: Cape Cod
EEA NUMBER	: 14414
PROJECT PROPONENT	: Town of Orleans
DATE NOTICED IN MONITOR	: November 7, 2018

Pursuant to the Massachusetts Environmental Policy Act (MEPA; M.G. L. c. 30, ss. 61-62I) and Section 11.10 of the MEPA regulations (310 CMR 11.00), I hereby determine that this project **does not require** an Environmental Impact Report (EIR).

Original Project and Procedural History

The Orleans Comprehensive Wastewater Management Plan (CWMP) calls for the 20-year phased construction of a wastewater collection system and new, centralized Wastewater Treatment Facility (WWTF) as well as implementation of non-structural program elements to achieve reductions in nitrogen loading to coastal embayments over a 20-year period. Specifically, the CWMP includes: construction of a 0.64 million gallons per day (mgd) WWTF at the Tri-Town Septage Treatment Facility on Overland Way; installation of 74 miles of sewer pipes and 63 pump stations in six construction phases to treat wastewater from 2,800 properties along Pleasant Bay, Town cove, and the Nauset and Rock Harbor watersheds (referred to as the Core Program); employing an adaptive management plan (AMP) that includes compliance with

Total Maximum Daily Load (TMDL) requirements, monitoring for nitrogen loading reductions, and making changes to the CWMP as necessary in response to new data; and evaluating opportunities to accommodate additional wastewater flows from Eastham and/or Brewster (referred to as the Regional Program). The CWMP was last reviewed by MEPA on January 28, 2011 when the Secretary issued a Certificate on the Single EIR which indicated it adequately and properly complied with MEPA and its implementing regulations.

Project Change

As described in the Notice of Project Change (NPC), the primary change is the relocation of the effluent disposal site from the Tri-Town Septage Treatment Facility to 32 Lots Hollow Road; 43 Lots Hollow Road is proposed as a reserve site. The NPC also described construction of a new effluent force main (4,805 linear feet (lf)) to convey flow from the WWTF site to the disposal site and a change to the effluent disposal technology from rapid infiltration sand beds to a vertical wick discharge. As described in the NPC, construction of the WWTF at Overland Way will be expanded in phases. The first phase will accommodate an initial phase of the Core Program with a design flow of approximately 250,000 gallons per day (gpd), including 16,000 gpd of septage handling. The final design capacity of the WWTF remains 0.64 mgd as previously identified in the Single EIR. Construction of the WWTF at the Overland Way location will occur wholly within previously disturbed areas of the site. The NPC indicated the new effluent disposal location was selected to avoid impacts to archaeological resources and mapped rare species habitat present at the Tri-Town Septage Treatment Facility site. According to the NPC, the change in disposal technology will also reduce the amount of land required for the discharge.

Project Site

The effluent disposal location is at 32 Lots Hollow Road (3.88 acres); 43 Lots Hollow Road (1.77 acres) is proposed as a reserve site. Both parcels are municipally owned and are located south of the Route 6 and Route 6A interchange in Orleans. The disposal locations are underlain by Harwich Outwash Plain Deposits, a very permeable soil consisting primarily of medium to very coarse sand and pebble to cobble gravel. Groundwater at both locations flows north-northwesterly towards the Namskaket and Little Namskaket Creeks. The NPC indicated that the effluent disposal locations do not contain wetland resource areas and are not located in Priority and/or Estimated Habitat as mapped by the Division of Fisheries and Wildlife's (DFW) Natural Heritage and Endangered Species Program (NHESP) or an Area of Critical Environmental Concern (ACEC). The NPC indicated that the groundwater mound and effluent discharge will eventually reach the Inner Cape Cod Bay ACEC which is designated as an Outstanding Resource Water (ORW) under the Massachusetts Surface Water Quality Standards (314 CMR 4.00).

Jurisdiction and Permitting

The CWMP is undergoing MEPA review and is subject to preparation of a Mandatory EIR pursuant to 301 CMR 11.03(5)(a)(3) of the MEPA regulations because it requires State Agency Actions and will result in the construction of one or more new sewer mains of ten or

more miles in length. The Single EIR indicated that implementation of the CWMP will require a Groundwater Discharge Permit (GWDP) from the Massachusetts Department of Environmental Protection (MassDEP) and may require a Conservation and Management Permit from the NHESP and a Non-Vehicular Access Permits from the Massachusetts Department of Transportation (MassDOT).[1]

The CWMP will require an Order of Conditions from the Orleans Conservation Commission (or in the case of an appeal, a Superseding Order of Conditions from MassDEP) and a National Pollutant Discharge Elimination System (NPDES) Construction General Permit from the U.S. Environmental Protection Agency (EPA). It may require a Section 404 Permit from the U.S. Army Corps of Engineers (ACOE) and Federal Consistency Review by the Office of Coastal Zone Management (CZM).

The NPC indicated that the project changes continue to require a GWDP from MassDEP and a Non-Vehicular Access Permit from MassDOT for installation of the effluent sewer main beneath Route 6, a state-jurisdictional roadway. The project change will not require a CMP from NHESP.

As anticipated in the Single EIR, the Town has applied for State Financial Assistance in the form of a $45 million loan from the Clean Water State Revolving Fund (SRF) to plan, design, and implement the CWMP. Therefore, MEPA jurisdiction is broad and extends to all aspects of the project that are likely, directly or indirectly, to cause Damage to the Environment, as defined in the MEPA regulations.

Environmental Impacts and Mitigation

As described in the NPC, the project changes will decrease land alteration (from 6.5 acres to 4 acres), decrease impervious area (from 6 acres to 4 acres), and eliminate permanent impacts to mapped rare species habitat (from 4.9 acres). The project changes will add 4,805 linear feet (lf) of new sewer main (74.91 total miles). The project changes will not directly impact wetland resource areas. The NPC indicated that implementation of the CWMP will improve water quality through elimination of failing septic systems which will increase protection for the Inner Cape Cod Bay ACEC.

As described in the NPC, the project changes do not require modification of any previously identified mitigation measures or draft Section 61 Findings. Measures to avoid, minimize, and mitigate environmental impacts include: the use of erosion and sediment control measures during construction, implementation of dust control measures, restrictions on work hours, and limiting areas of disturbance by locating work within previously disturbed areas where possible.

[1] The Single EIR Certificate indicated that implementation of the CWMP also required a Chapter 91 (c.91) License, and 401 Water Quality Certificate (WQC) from MassDEP. Information provided with the NPC clarified that this was erroneous and these Permits are not required. Information provided with the NPC also clarified that implementation of the CWMP will require Non-Vehicular Access Permits from MassDOT.

Review of the NPC

The NPC included a description of the project as previously presented in the Single EIR, described the project changes, and included conceptual site plans. It identified potential environmental impacts and described measures to avoid, minimize, and mitigate said impacts. The NPC included a "Groundwater Discharge Hydrogeologic Evaluation – 32 and 43 Lots Hollow Road" (dated August 2, 2018) which assumed a maximum effluent discharge of 500,000 gpd at each location and included a summary of pump test data and field investigations, groundwater flow modeling, and groundwater mounding analysis.

The Proponent's consultant provided supplemental information to the MEPA Office and MassDEP regarding agency actions, vegetation monitoring, nitrogen loading, and freshwater flows to facilitate MEPA review.[2] This information provided a revised table which identified anticipated nitrogen loading for each receiving watershed based on particle tracking, and clarified that no additional nitrogen load will reach Pleasant Bay. A primary focus of MassDEP's review of the GWDP application will be to ensure that the project does not introduce additional nitrogen into impaired waterbodies without an appropriate offset. I refer the Town to comments from MassDEP which indicate this information will be reviewed thoroughly as part of the GWDP application. The Town should provide this and any other supporting information on nitrogen loading that is prepared during the GWDP process to CZM for their review.

Comments from MassDEP generally support the project and acknowledge it is an important first step in addressing the Town's nitrogen mitigation strategy. I refer the Town to comments from the Massachusetts Historical Commission (MHC) which requests additional information to evaluate archaeological and historic impacts. Comments from MassDOT identify information that should be provided during permitting.

Wastewater/Water Quality

Supplemental information from the Town's consultant clarified that the nitrate load from the effluent discharge will eventually reach Cape Cod Bay, Little Namskaket Creek, Namskaket Creek, Town Cove, Rock Harbor, and Boat Meadow River. This supplemental information clarified that the nitrate load to each watershed, with the exception of Cape Cod Bay, will be offset by the nitrate load removed through installation of the wastewater collection system and treatment at the WWTF. This information is summarized in Table 1 below. The NPC indicated that the additional nitrogen load to Cape Cod Bay is not anticipated to cause adverse water quality or benthic habitat impacts as the bay experiences significant daily tidal flushing.

As described in the NPC, the effluent discharge and groundwater mound will occur within the Inner Cape Cod Bay ACEC which includes Cape Cod Bay, Namskaket and Little Namskaket Creeks, Boat Meadow River, and Rock Harbor. The NPC indicates that use of vertical wicks to dispose of effluent will keep the discharge deep enough to avoid impacting coastal resources within the ACEC. Additionally, implementation of the CWMP is anticipated to reduce nutrient and pathogen impacts to these water bodies as sub-standard and failing septic systems are eliminated and properties are connected to the sewer system. I refer the Town to

[2] Emails from Jennifer Doyle-Breen (AE COM) to Page Czepiga (MEPA Office) sent 11/19/18 and 11/21/18.

comments from CZM which recommend the Town summarize and share this information to support assessment of water quality relative to long-term goals.

Table 1

Watershed	Nitrate Load (kg/yr)		
	Nitrate to WWTF	Nitrate from WWTF	Nitrate Removed from Watershed
Town Cove	3,536	429	3,107
Boat Meadow Harbor	36	30	6
Rock Harbor Stream	3,000	307	2,693
Little Namskaket Creek	825	767	58
Namskaket Creek	470	31	439
Cape Cod Bay	0	1,502	-1,502
Pleasant Bay	0	0	0
Total	**7,867**	**3,066**	**4,801**

The NPC indicated that groundwater mounding in Namskaket and Little Namskaket Creek systems may cause a change in vegetation which could facilitate growth in freshwater invasive species. The NPC indicated a vegetation monitoring plan will be developed in consultation with MassDEP to identify shifts in plant cover and triggers for mitigation. I refer the Town to comments from the Division of Marine Fisheries (DMF) which recommends that surveys be performed prior to discharge to establish a pre-impact baseline.

Comments from CZM note that implementation of remaining portions of the CWMP will locate components of the wastewater collection infrastructure within coastal AE and VE flood zones. CZM recommends that the Town consider alternative locations for infrastructure and/or implement adaptation and resiliency measures to protect infrastructure from the vulnerabilities associated with the effects of climate change. I expect the Town will continue to evaluate alternative locations outside the floodplain for system components, such as pump stations, and will incorporate design features to increase the resiliency of the infrastructure from effects associated with sea level rise and changes in precipitation.

Construction Period

The Town will be required to implement stormwater management measures during construction in accordance with the NPDES Construction General Permit. The Town should implement measures to prevent and minimize dust, noise, and odor nuisance conditions that may occur during construction of the project. All construction activities should be undertaken in compliance with the conditions of all State and local permits. The Town should also minimize idling of construction equipment in accordance with the Air Quality regulations (310 CMR 7.11) which limit vehicle idling to five minutes. I encourage the Town to select project contractors that have installed retrofit emissions control devices, or vehicles that use alternative fuels, and to participate in the Clean Air Construction Initiative (CACI) in an effort to reduce emissions of volatile organic compounds, carbon monoxide and particulate matter (VOC, CO and PM) from diesel-powered equipment. Off-road vehicles are required to use ultra-low sulfur diesel fuel (ULSD).

Future NPC

This NPC indicated that the Town is planning to reduce the scope of the original sewer plan and to incorporate alternative nitrogen reduction strategies that are currently under review, including the use of permeable reactive barriers and deployment of shellfish. The Town's consultant indicated that these changes will be incorporated into a future NPC. I expect the next NPC will provide calculations and/or monitoring results to demonstrate that implementation of these measures will achieve identified nitrogen removal targets and/or include comprehensive information on how the effectiveness of these measures will be assessed and monitored. The future NPC should also provide an update on each of the core elements of the CWMP: Orleans WWTF, Core Program, Non-Structural Program Elements, Adaptive Management Plan, and Regional Wastewater Management Opportunities. The update should describe each element, identify any changes since the Single EIR was reviewed, and include an updated summary of environmental impacts associated with implementation of the CWMP. It should also include an updated summary of mitigation measures, draft Section 61 Findings, and an updated schedule for implementation of the remaining phases of the CWMP.

I expect the NPC will also address Executive Order 569: *Establishing an Integrated Climate Change Strategy for the Commonwealth* (EO 569), which was issued in September 2016. EO 569 recognizes the serious threat presented by climate change and directs agencies within the administration to develop and implement an integrated strategy that leverages state resources to combat climate change and prepare for its impacts. Specifically, the future NPC should provide an analysis and discussion of the vulnerabilities of the wastewater collection and treatment system to the potential effects of climate change and identify design features that could increase the resiliency of the proposed infrastructure under future climate change conditions. To assist in the evaluation of climate change resiliency and adaptation measures, the Town should review the New England Interstate Water Pollution Control Commission's *"Preparing for Extreme Weather at Wastewater Utilities: Strategies and Tips"* (September 2016).[3]

Conclusion

The NPC has sufficiently defined the nature and general elements of the project for the purposes of MEPA review and demonstrated that the project's environmental impacts can be avoided, minimized, and/or mitigated to the extent practicable. Based on the information in the NPC and after consultation with State Agencies, I find that no further MEPA review is required at this time. I encourage the Town to consult with the MEPA Office prior to filing a subsequent NPC.

December 7, 2018
Date

Matthew A. Beaton

[3] Available at: http://neiwpcc.org/wp-content/uploads/2017/10/9-20-2016-NEIWPCC-Extreme-Weather-Guide-for-web.pdf

Comments received:

11/19/2018	Division of Marine Fisheries (DMF)
11/27/2018	Massachusetts Department of Environmental Protection (MassDEP)
11/27/2018	Office of Coastal Zone Management (CZM)
11/28/2018	Natural Heritage and Endangered Species Program (NHESP)
11/21/2018	Massachusetts Historical Commission (MHC)
12/06/2018	Massachusetts Department of Transportation (MassDOT)

MAB/PRC/prc

The Commonwealth of Massachusetts
Executive Office of Energy and Environmental Affairs
100 Cambridge Street, Suite 900
Boston, MA 02114

Charles D. Baker
GOVERNOR

Karyn E. Polito
LIEUTENANT GOVERNOR

Matthew A. Beaton
SECRETARY

Tel: (617) 626-1000
Fax: (617) 626-1081
http://www.mass.gov/eea

April 19, 2019

CERTIFICATE OF THE SECRETARY OF ENERGY AND ENVIRONMENTAL AFFAIRS
ON THE
SECOND NOTICE OF PROJECT CHANGE

PROJECT NAME	: Town of Orleans – Comprehensive Wastewater Management Plan – Non-Traditional Technologies for Nitrogen Removal
PROJECT MUNICIPALITY	: Orleans
PROJECT WATERSHED	: Cape Cod
EEA NUMBER	: 14414
PROJECT PROPONENT	: Town of Orleans
DATE NOTICED IN MONITOR	: March 20, 2019

Pursuant to the Massachusetts Environmental Policy Act (MEPA; M.G. L. c. 30, ss. 61-62I) and Section 11.10 of the MEPA regulations (310 CMR 11.00), I hereby determine that this project **does not require** an Environmental Impact Report (EIR).

Original Project and Procedural History

The Orleans Comprehensive Wastewater Management Plan (CWMP) calls for the 20-year phased construction of a wastewater collection system and new, centralized Wastewater Treatment Facility (WWTF) as well as implementation of non-structural program elements to achieve reductions in nitrogen loading to coastal embayments over a 20-year period. Specifically, the CWMP includes: construction of a 0.64 million gallons per day (mgd) WWTF at the Tri-Town Septage Treatment Facility on Overland Way; installation of 74 miles of sewer pipes and 63 pump stations in six construction phases to treat wastewater from 2,800 properties along Pleasant Bay, Town Cove, and the Nauset and

Rock Harbor watersheds (referred to as the Core Program); an adaptive management plan (AMP) that includes compliance with Total Maximum Daily Load (TMDL) requirements, monitoring for nitrogen loading reductions, and making changes to the CWMP as necessary in response to new data; and evaluation of opportunities to accommodate additional wastewater flows from Eastham and/or Brewster (referred to as the Regional Program).

A Certificate on the Single EIR for the CWMP was issued on January 28, 2011 and indicated that it adequately and properly complied with MEPA and its implementing regulations. In January 2018, the Town submitted the first NPC. The NPC proposed to shift the location of the effluent disposal site from the Tri-Town Septage Treatment Facility to 32 Lots Hollow Road and identified 43 Lots Hollow Road as a reserve site. On December 7, 2018, I issued a Certificate on the first NPC in which I determined that the potential impacts associated with the project change did not require an EIR.

Second Notice of Project Change

The second NPC was submitted to incorporate the following two demonstration projects into the CWMP: a permeable reactive barrier (PRB) at Eldredge Park and oyster aquaculture in Lonnie's Pond. These demonstration projects utilize non-traditional technologies to remove nitrogen and were not previously included within the Town's CWMP. Both demonstration projects were deployed in 2016. The Town has monitored these projects and has two to three years of monitoring data with which to evaluate their effectiveness in removing nitrogen. The second NPC also provided an update on wastewater planning activities that have occurred since the 2011 CWMP.

Demonstration Project Sites

The PRB is located within Eldredge Park at 78 Eldredge Park Way in Orleans. Specifically, the PRB is located in the parking lot area between the Nauset Middle School playing fields and the Town-owned Eldredge Park baseball field. The 100-foot (ft) long PRB is oriented northwest to southeast, perpendicular to the northeasterly groundwater flow direction. Physical structures associated with the PRB include 42 two-inch diameter monitoring wells which are flush mounted and occupy less than 1 square foot (sf). Groundwater generally flows toward Town Cove which is located approximately 2,400 ft to the northeast. Lonnie's Pond (Pond) (also known as Kescayo-Gansett Pond) is located within the upper reaches of the Pleasant Bay watershed. The Pond contains mapped shellfish habitat for quahogs *(Mercenaria mercenaria)* and soft shell clams *(Mya arenaria).* According to the Division of Marine Fisheries (DMF), the Pond provides anadromous/catadromous fish passage and migration habitat for alewife *(Alosa pseudoharengus)* and american eel *(Anguilla rostrate).* Salt marsh is located around the shoreline of the Pond. The Pond is located within the designated Pleasant Bay Area of Critical Environmental Concern (ACEC). Neither demonstration project is located within Priority and/or Estimated Habitat as mapped by the Division of Fisheries and Wildlife's (DFW) Natural Heritage and Endangered Species Program (NHESP).

Jurisdiction and Permitting

The CWMP is undergoing MEPA review and is subject to preparation of a Mandatory EIR pursuant to 301 CMR 11.03(5)(a)(3) of the MEPA regulations because it requires State Agency Actions and will result in the construction of one or more new sewer mains of ten or more miles in length.

Implementation of the CWMP will require a Groundwater Discharge Permit (GWDP) from the Massachusetts Department of Environmental Protection (MassDEP) and may require a Conservation and Management Permit (CMP) from the NHESP and a Non-Vehicular Access Permit(s) from the Massachusetts Department of Transportation (MassDOT).

Implementation of the CWMP will require an Order of Conditions from the Orleans Conservation Commission (or in the case of an appeal, a Superseding Order of Conditions from MassDEP) and a National Pollutant Discharge Elimination System (NPDES) Construction General Permit from the U.S. Environmental Protection Agency (EPA). It may require a Section 404 Permit from the U.S. Army Corps of Engineers (ACOE) and Federal Consistency Review by the Office of Coastal Zone Management (CZM).

The second NPC indicated that the aquaculture demonstration project in Lonnie's Pond will require DMF's certification of the private shellfish aquaculture license pursuant to MGL c. 130 § 57. The PRB demonstration project does not require any Agency Actions.

The Town has applied for State Financial Assistance in the form of a $45 million loan from the Clean Water State Revolving Fund (SRF) to plan, design, and implement the CWMP. Therefore, MEPA jurisdiction is broad and extends to all aspects of the project that are likely, directly or indirectly, to cause Damage to the Environment, as defined in the MEPA regulations.

Environmental Impacts and Mitigation

As described in the second NPC, the project changes will increase the total site acreage (from 27 acres to 27.37 acres) and will increase impacts to Land Under Water (LUW) (from 0 sf to 6 sf). The NPC will not change impacts to land alteration (4 acres), impervious area (4 acres), or rare species habitat (4.9 acres) from those previously reviewed.

Measures to avoid, minimize, and mitigate impacts include: comprehensive water quality monitoring plan for Lonnie's Pond, use of black floating bags to minimize visual impacts, requirements for annual removal of aquaculture gear, commitments to address abutters concerns (visual impacts, noise, restricting work hours, limiting parking), and rotating oyster bags across several locations.

Review of the NPC

The second NPC included a description of the project as previously proposed, described the two demonstration projects, and included conceptual site plans. It identified potential environmental impacts and described measures to avoid, minimize, and mitigate impacts associated with the two projects.

Comments from MassDEP, CZM, and DMF emphasize the importance of the Town continuing its CWMP planning process; including continued evaluation of more traditional means of nutrient reduction and source reduction strategies. Comments from MassDEP identify additional information that should be addressed in subsequent submittals and emphasize the importance of providing a comprehensive update of the CWMP.

Wastewater Planning

The NPC provided an update on wastewater planning activities that have occurred since the CWMP was reviewed by MEPA in 2011. In 2014, the Town convened the Orleans' Water Quality Advisory Panel (OWQAP) to investigate the use of non-traditional technologies to achieve nitrogen removal goals. In 2015, the OWQAP developed a written Consensus Agreement and associated Consensus Plan figure which proposed a hybrid approach to nitrogen removal consisting of traditional and non-traditional technologies that would provide the Town with a more cost-effective strategy for reducing nitrogen in Rock Harbor, Nauset Marsh, Pleasant Bay, Namskaket, and Little Namskaket Watersheds. The Town did not formally amend the CWMP to incorporate the hybrid approach. The Consensus Agreement identified the following non-traditional technologies: Permeable Reactive Barriers (PRB), floating constructed wetlands, shellfish aquaculture, and coastal habitat restoration reefs. As described below, two technologies have progressed to the demonstration project phase (PRBs and aquaculture). The second NPC indicated that floating constructed wetlands were dismissed due to insufficient data to evaluate the effectiveness of this technology. The second NPC indicated the Town is currently evaluating locations to implement a Nitrogen Reducing Biofilter (NRB) demonstration project.

In 2018, the Pleasant Bay Alliance (PBA), comprised of Orleans, Chatham, Brewster, and Harwich, developed the *Pleasant Bay Targeted Watershed Management Plan* (TWMP). The TWMP documented the mitigation measures that each municipality must implement to reduce its share of nitrogen contribution to Pleasant Bay in accordance with TMDL requirements. Oyster aquaculture in Lonnie's Pond was identified in the TWMP as one of the measures the Town must implement. In August 2018, MassDEP issued a Watershed Permit that authorized work to implement the recommendations in the TWMP and achieve identified water quality improvements. The Watershed Permit established performance standards and timeframes under an adaptive management framework for the actions outlined in the TWMP, including aquaculture at Lonnie's Pond. The Watershed Permit requires the submittal of monitoring data to MassDEP to inform development of a nitrogen removal credit for aquaculture at Lonnie's Pond. The Town has not determined whether it will implement a full-scale aquaculture program. The Watershed Permit also requires the Town to amend the CWMP by 2023. As described below in greater detail, the Town should submit a NPC to the MEPA Office consisting of a comprehensive amendment to the CWMP.

Demonstration Projects

The second NPC indicated the Town is considering implementing the following non-traditional technologies to reduce or attenuate nitrogen loading: additional PRB demonstration project(s), additional aquaculture demonstration project(s), coastal habitat restoration reef demonstration project(s), and NRB demonstration project(s). As noted previously, the second NPC provided a description of the PRB at Eldredge Park and the Lonnie's Pond aquaculture demonstration projects; identified potential environmental impacts and included monitoring data for both projects (Attachments 4 and 5 of the second NPC).

The second NPC did not address environmental impacts associated with other non-traditional technologies or additional demonstration projects.

The PRB was installed in November 2016 and has been monitored quarterly since January 2017. Data collected includes the lateral and vertical movement of the emulsified vegetable oil through the ground, the extent of nitrogen reduction in the groundwater, and the migration path of the groundwater plume. The Town will complete monitoring in the fall of 2019. Data provided with the second NPC indicated reductions in nitrate concentrations over baseline conditions at some downstream monitoring wells. According to the second NPC, the ability of the PRB to decrease nitrate concentrations is reduced due to locally variable groundwater flow conditions and a previously unidentified upstream source of high nitrate concentration. The Town is evaluating corrective actions, including expanding and realigning the PRB and increasing the number of monitoring wells. The Town is evaluating additional locations for PRBs; a location has not been selected.

The Town conducted the aquaculture demonstration project in Lonnie's Pond for three years (2016 - 2018) to evaluate nitrogen uptake under various oyster stocking density scenarios and to determine logistics of implementing oyster aquaculture. According to the second NPC, Lonnie's Pond was selected as the preferred location for the demonstration project because of its favorable growing conditions and site specific characteristics which facilitates monitoring water quality and sediment denitrification. The Town collected data on temperature, salinity, total nitrogen, and other parameters in accordance with the requirements of the Watershed Permit. Oyster culture was deployed in floating bags, attached to long-lines, and anchored by a series of telescoping augurs. In 2016, 200,000 oysters (averaging 10.5% nitrogen content each) were deployed over a 0.22-acre area and removed 25.9 kilograms (kg) of nitrogen by uptake. In 2017, 600,000 oysters (averaging 10.3% nitrogen content each) were deployed over a 0.19-acre area and removed 28.1 kg of nitrogen. In 2018, oysters were deployed over a 0.37-acre area. Data from 2018 is still being analyzed. Results from the first two years indicate that a 1-acre, full-scale aquaculture project could achieve the annual reductions in nitrogen identified in the Massachusetts Estuaries Project (MEP) for Lonnie's Pond (300 kg/year) and could support attainment of TMDLs for this sub-embayment.

The aquaculture activities in Lonnie's Pond were conducted by the Town under the authority of their municipal propagation permit. According to the second NPC, the Town has elected to contract with a third party to continue the aquaculture demonstration project at Lonnie's Pond during 2019 and beyond. This will require certification of a private aquaculture license by DMF under MGL 130 §57. Comments from MassDEP – Waterways confirm that this demonstration project will not require a Chapter 91 (c.91) License as it is a seasonal installation that is not intended to remain in place permanently.

Approximately 5.5 million 2-3 millimeter (mm) seed oysters will be deployed by June 1. The project will consist of 2,040 black, floating bags over a 0.37-acre area of Lonnie's Pond. Gear will be installed annually in the spring and removed no later than December 15th in any given year. The bags will be located in two areas of the Pond (the south side and northeast side). Each location will be divided into six sections and only two of the six sections in each location will be occupied in any given year. The Town anticipates that the project will remove 75 kg of nitrogen. The Town will hire an Aquaculture Contractor who will be responsible for purchasing, transporting, installing, maintaining, and removing the shellfish. The Town will also hire a Monitoring Contractor to conduct water quality monitoring in Lonnie's Pond and to calculate the amount of nitrogen uptake by the oysters on an annual basis. The second NPC identified requirements for the contractor regarding: contingency plans for catastrophic

events, monitoring and reporting, shellfish sampling, time-of-year restrictions for gear removal, and development of a Quality Assurance Project Plan (QAPP) for review by the Town and MassDEP.

The Town will continue to evaluate these two demonstration projects; no decisions have been made in regard to full-scale implementation of these technologies. Consultation with MassDEP is necessary to establish the amount of nitrogen removal credit that could be assigned to each technology. Upon establishment of a nitrogen removal credit, the Town may propose to reduce the sewer area outlined in the 2011 CWMP with a combination of these non-traditional technologies. The Town may continue implementation and monitoring of the Lonnie's Pond aquaculture demonstration project and the PRB; however, full-scale implementation of non-traditional nitrogen removal technologies must be reviewed through the Amended CWMP.

Amended CWMP/NPC

The Town must amend its CWMP by 2023 as required by the MassDEP Watershed Permit. The Amended CWMP will be subject to MEPA review in the form of a NPC. The Amended CWMP/NPC should provide an update on each of the core elements of the CWMP (as applicable), describe each element, identify any changes since the Single EIR was reviewed, and include an updated summary of environmental impacts associated with implementation of the CWMP.[1]

The Amended CWMP/NPC should include an updated summary of mitigation measures, draft Section 61 Findings, and an updated schedule for implementation of the remaining phases of the CWMP. It should also address Executive Order 569: *Establishing an Integrated Climate Change Strategy for the Commonwealth* (EO 569), which was issued in September 2016. I refer the Town to the Certificate on the first NPC for additional guidance on EO 569. The Town should consult with MassDEP and the MEPA Office prior to preparing the NPC.

The Amended CWMP/NPC should address the extent to which full-scale implementation of non-traditional nitrogen removal technologies will reduce the sewer collection area or other infrastructure components identified in the 2011 CWMP. The Amended CWMP/NPC should identify the proposed sites, include maps and plans at a reasonable scale that clearly locate and delineate project elements and environmental resources within the project area. The Amended CWMP/NPC must include a list of required permits and a timetable and cost estimate for each non-traditional technology. It should identify the estimated percent of nitrogen removal that could be achieved by each proposed technology compared to the necessary nitrogen removal identified as necessary by the MEPs for these watersheds**.** I refer the Town to the MassDEP comment letter for additional guidance on information that should be provided in the Amended CWMP/NPC. It should also include an alternatives analysis that describes siting criteria, and identifies potential environmental impacts associated with each alternative. The Amended CWMP/NPC should identify measures to avoid, minimize and mitigate environmental impacts. To the extent that agency comments on the Single EIR, first and/or second NPC identified issues, concerns and/or provided recommendations associated with a non-traditional technology, they should be addressed in the NPC.

[1] Core elements of the CWMP include: Orleans WWTF, Core Program, Non-Structural Program Elements, Adaptive Management Plan, and Regional Wastewater Management Opportunities.

The narrative within the second NPC referred to additional evaluations, data, and monitoring results provided within a series of annual reports, which were provided electronically. The information itself was not described or summarized within the narrative of the second NPC. All future submittals should provide a full and self-contained description and analysis of the project for the MEPA record, including a summary of monitoring data. It should provide additional narrative to explain and support the analysis of the project's impacts and mitigation, and extract relevant documentation and tables from technical appendices to supplement the narrative.

Conclusion

The NPC has sufficiently defined the nature and general elements of the two demonstration projects for the purposes of MEPA review and demonstrated that environmental impacts can be avoided, minimized, and/or mitigated to the extent practicable. Based on the information in the NPC and after consultation with State Agencies, I find that no further MEPA review is required at this time. I encourage the Town to consult with the MEPA Office prior to filing the Amended CWMP/NPC.

April 19, 2019
Date

Matthew A. Beaton

Comments received:

04/04/2019 Massachusetts Historical Commission (MHC)
04/08/2019 Natural Heritage and Endangered Species Program (NHESP)
04/09/2019 Office of Coastal Zone Management (CZM)
04/09/2019 Division of Marine Fisheries (DMF)
04/09/2019 Massachusetts Department of Environmental Protection (MassDEP) – Southeast Regional Office
04/12/2019 MassDEP – Waterways Program

MAB/PRC/prc

ATTACHMENT B

CCC APPROVAL OF THE TOWN OF ORLEANS CWMP AS A DRI

3225 MAIN STREET • P.O. BOX 226
BARNSTABLE, MASSACHUSETTS 02630

(508) 362-3828 • Fax (508) 362-3136 • www.capecodcommission.org

CAPE COD
COMMISSION

DATE: October 13, 2011

TO: George Meservey
Director of Planning & Community Development
Town Hall
19 School Street
Orleans, MA 02653-3699

FROM: Cape Cod Commission

RE: Development of Regional Impact
Cape Cod Commission Act, Sections 12 & 13

APPLICANT: Town of Orleans Board of Selectmen

PROPERTY OWNER: Town of Orleans at Town Hall, 19 School Street, Orleans

PROJECT #: EOEEA #14414 – DRI # 09008/JR09008

PROJECT: Town of Orleans Comprehensive Wastewater Management Plan

LOCATION: Tri-Town Septage Plant, Overland Way, and Town-wide

RECORDING:
Certificate of Title # 88668 Lots 7, 8, 9, 10, 11, 12, 21, 22, and 23 on Plan 31048-B
Certificate of Title # 134857 Lot 13 on Plan 31048-B
Book 3483 Page 69
Book 4304 Page 171

DECISION OF THE CAPE COD COMMISSION - SUMMARY

The Cape Cod Commission (Commission) hereby approves with conditions the application of the Town of Orleans (Town) for the Orleans Comprehensive Wastewater Management Plan (CWMP) as a Development of Regional Impact (DRI) in accordance with Sections 12 and 13 of the Cape Cod Commission Act (Act). This decision is rendered pursuant to a vote of the Cape Cod Commission on October 13, 2011.

PROCEDURAL HISTORY

In May 2009, the Town of Orleans sought voluntary joint MEPA/Commission review of the CWMP through submission to MEPA of an Expanded Environmental Notification Form/Draft CWMP. The Commission and MEPA held a joint hearing on the draft CWMP/Expanded Environmental Notification Form (EENF) on June 16, 2009, where a Commission

Subcommittee formulated comments for inclusion into the MEPA scope for the EIR. On July 10, 2009, the Secretary of EOEEA issued a Certificate on the draft CWMP/EENF that set out the EIR scope and also allowed the Town to proceed with an S/FEIR.

The Commission held a joint hearing with MEPA on January 18, 2011 on the S/FEIR, where the Subcommittee formulated comments and voted to submit a comment letter to MEPA on the Single/Final EIR. On January 28, 2011, the Secretary of EOEEA issued a Certificate on Orleans' revised CWMP S/FEIR stating, *"the project adequately and properly complies with the Massachusetts Environmental Policy Act (MEPA) and its implementing regulations."* Section 7(c)(vi)[1] of the Commission's *Enabling Regulations* stipulate that *"the Commission shall hold a public hearing to review the project within 45 days of the Secretary's certification of the adequacy of the final EIR..."*

The Commission held the first public hearing on March 1, 2011 at Orleans Town Hall to consider the Town's CWMP as a Development of Regional Impact and additional public hearings and subcommittee meetings as listed below.

Date	Meeting Type	Venue
March 1, 2011	Public Hearing	Orleans TH
March 24, 2011	Public Hearing	CCC Library
April 14, 2011	Public Hearing	Assembly
April 28, 2011	SubCom	CCC Library
May 24, 2011	Public Hearing	CCC Library
June 9, 2011	Subcom	CCC Library
June 15, 2011	SubCom	Brewster TH
July 7, 2011	SubCom	Assembly

At a meeting on 6/15/11 at Brewster Town Hall, a Commission Subcommittee voted to forward the CWMP to the full Commission for consideration. On October 13, 2011, the final public hearing was held before the full Commission on the draft written DRI decision for the Orleans CWMP. The Commission voted unanimously to approve the project and draft decision as a DRI with conditions.

PROJECT DESCRIPTION

The Comprehensive Wastewater Management Plan (CWMP)/Single Final Environmental Impact Report (SFEIR) from the Town of Orleans and its consultants provides a strategy for wastewater management to achieve reductions of nitrogen loading to restore and protect Orleans's marine embayments. The CWMP also addresses fresh water ponds; areas with septic system problems associated with frequent pumping, intensity of use, and mounded systems; provides modest capacity for expanded residential housing in the commercial district; opportunities for regional management; and an adaptive management approach for its implementation.

The CWMP proposes a six-phase wastewater management plan that will collect and treat up to an annual average wastewater flow of 0.64 million gallons per day (MGD) from 2,800 properties to meet nutrient Total Maximum Daily Loads (TMDLs) for: Pleasant Bay, North side embayments to Cape Cod Bay, and Nauset Marsh/Town Cove. The CWMP also accommodates

septage and sludge handling and proposes 5 clustered treatment systems which will hasten nutrient removal. The CWMP also addresses estimated treatment capacity, fresh water pond quality, problematic septic systems, and modest growth in the Central village. The wastewater flow analysis reported in the CWMP reflects a detailed build-out analysis that predicts a 26% increase in residential flows and an 8% increase in commercial flows over a 15- to 20-year implementation period. The Phased Plan also targets nutrient reduction through certain non-structural elements, including a fertilizer control program, stormwater management, a water conservation program coupled with a wastewater flow and load reduction initiative, enhancement of embayment flushing rates, and land use controls.

The 2008 estimated capital cost of the CWMP is $150 million dollars over the 15 to 20 year implementation period. The average cost to a homeowner is estimated at $2,600 per year. The Town has adopted a cost recovery policy that incorporates property tax assessment to pay for 80% of the capital costs and relies on betterments for the remaining 20% of the costs.

Wastewater management planning has been underway in Orleans since the year 2000. Commission Water Resources staff has been involved with the project from the beginning. Staff has provided direct technical assistance and oversight of grants through the County's former Wastewater Implementation Committee and Water Protection Collaborative. Commission Water Resources staff has reviewed and commented on all aspects of the CWMP, including the scope of work for the CWMP in February 2006, the initial Needs Assessment of February 2007, the Alternatives Screening Report of December 2007, the Detailed Evaluation of Alternatives in May 2008, the Recommended Plan in August of 2008, the Draft CWMP in 2009, and the Single/Final EIR in 2010/2011. Commission staff met frequently with Town and Massachusetts Department of Environmental Protection (DEP) officials and attended public hearings on the project. The County funded an independent engineering review of the CWMP dated September 30, 2010, which concluded the CWMP was *"based on good engineering judgment and scientific bases."*

JURISDICTION

This project comes under the jurisdiction of the Commission pursuant to Section 2(d)(i) of the Commission *Enabling Regulations Governing Review of Developments of Regional Impact*, which requires proposed development for which an EIR is required to be prepared under the provisions of MEPA to undergo DRI review.

MATERIALS SUBMITTED FOR THE RECORD

In addition to the list of materials submitted for the record (see Table 1 below), the application and notices of public hearings relative thereto, Commission staff's notes and correspondence, the minutes of public meetings and hearings, and all other written submissions received in the course of the proceedings are hereby incorporated into the record by reference.

TABLE 1: Materials Submitted for the Record

Materials from Cape Cod Commission	***Date Sent***
Letter, Andrea Adams (AA) to GM, Comments on Natural Resources and Historic/archeological resources at Tri-Town site	2/9/09
Draft Staff Report on CWMP/Expanded ENF	6/9/09
Hearing Notice – Joint hearing	6/16/09
Minutes – Joint Hearing	6/16/09
Fax cover sheet, Copy of 6/26/09 Subcommittee letter to Secretary on	6/29/09

CWMP/Expanded ENF	
Copy of 6/26/09 Subcommittee letter to MEPA on Expanded ENF	6/29/09
Email, AA to GM, DRI process	2/3/10
Email, Kristy Senatori (KS) to Tom Cambareri (TC), Scheduling of review	12/14/10
Email, AA to GM, DRI process	
Email, AA to GM, DRI process as it relates to MEPA review	12/14/10
Email, AA to Nicholas Zavolas (NZ), MEPA Analyst, Publication of Single/Final EIR in Monitor	12/15/10
Email, AA to staff, Request for comments on Single/Final EIR	12/15/10
Email, AA to Subcommittee, Scheduling hearing	12/22/10
Email, AA to GM, Scheduling of hearing dates	12/27/10
Email, AA to GM, NZ and Town Clerk, Notice for hearing	12/28/10
Letter, Joyce Brookshire, Eastham Commission Member, Resignation from OCWMP Subcommittee	1/3/11
Email, AA to GM, Hearing agenda	1/6/11
Cover Memo, AA to Subcommittee, Transmittal of information from the record: 6/19/09 draft Minutes, CD of CWMP/Single Final EIR as PDFs, Executive Summary, Table of Contents, Copy of 11/10/09 information from Mary Hartley, 2/23/10 letter from MHC	1/6/11
Email, AA to GM, List of Subcommittee members	1/7/11
Email, AA to Augusta McKusick, Confirming receipt of comment letter	1/10/11
Email, Tom Cambareri (TC) to GM, Copy of CWMP at local library	1/11/11
Email, AA to GM and NZ, Staff report on Single/Final EIR	1/11/11
Email, AA to Subcommittee, Staff Report and Email from McKusick	1/11/11
Cover Memo, AA to Subcommittee: Copy of Staff Report and Email from McKusick	1/11/11
Staff Report	1/11/11
Email, Patty Daley (PD) to NZ, Email from Michael C. Farber (MF)	1/13/11
Email, PD to MC and others, Concerning postponement of Joint Hearing on 1/18/11	1/13/11
Telephone Log sheet, AA with Beverly Carney (BC), MEPA process	1/14/11
Cover Memo, AA to Subcommittee: 1/12/11 letter from Carole Ridley, 1/13/11 Email from Fran Meaney to PD, 1/13/11 Email from Michael Farber (MF) to PD, 1/13/11 Email from MF to PD, 1/13/11 Email from MF to KS, 1/13/11 Email from PD to NZ, 1/3/11 Email from PD To MF, 1/13/11 Email from Kevin Cassidy to PD, 1/13/11 Email from MF to PD, 1/13/11 Email from MF to PD	1/14/11
Hearing Agenda for 1/18/11	1/18/11
Hearing Outline for Subcommittee for 1/18/11	1/18/11
Email, AA to Roger Putnam, Hearing Outline	1/18/11
Hearing Notice – Joint Hearing	1/18/11
Sign In Sheet – Joint Hearing	1/18/11
Minutes – Joint Hearing	1/18/11
Email, AA to Subcommittee, PDFs of Emails received	1/18/11
Color PowerPoint Presentation, Water Resources	1/18/11
Color Power Point Presentation, Staff Report	1/18/11
Cover Letter, Roger Putnam, Subcommittee Chair, to Secretary, Transmittal of staff report as comment letter on Single/Final EIR	1/18/11

Email, AA to GM and NZ, Copy of Subcommittee comment letter	1/19/11
Email, AA to Subcommittee, Copy of comment letters and Emails received	1/20/11
Email, TC to AA, Response regarding MF public records request	2/8/11
Email, AA to MF, Response to his 2/8/11 public records request	2/9/11
Email, AA to GM, Hearing Notice	2/9/11
Email, AA to GM, Request for comment on local criteria for DRI approval	2/9/11
Email, AA to GM and Town Clerk, Copy of Hearing Notice	2/10/11
Email, AA to GM, Confirmation of receipt of comments on local criteria for DRI approval	2/11/11
Email, AA to GM, Discussion of Staff report	2/17/11
Staff Report	2/22/11
Cover Memo, AA to Subcommittee except Peter Monger, Transmittal of information submitted for the record: Staff Report, Draft Minutes from 1/18/11 hearing, Copies of comment letters and Emails, CD of Town's PowerPoint presentation at 1/18/11 hearing, CD of information & comments from PA	2/22/11
Cover Memo, AA to Peter Monger, Subcommittee Member, Transmittal of information received: Staff Report, Commission staff PowerPoint presentations at 1/18/11 hearing, Information provided to Subcommittee since 1/11/11, Draft Minutes from 1/18/11 hearing, Emails and comment letters received since 1/11/11, CD of Town's PowerPoint presentation at 1/18/11 hearing, CD of information from PA	2/22/11
Email, AA to GM, Copy of Staff report	2/22/11
Email, AA to Susan Leven, Brewster Town Planner, Copy of Staff report	2/22/11
Email and colored attachments, Elizabeth Taylor, Subcommittee member (ET), to Andrea Adams	2/23/11
Email, AA to ET and KS: Confirm receipt of information	2/23/11
Email, ET to AA: Not going to continue to be on Subcommittee	2/23/11
Email, AA to ET: Confirmation of receipt of Email	2/24/11
Email, AA to ET: Response to request for draft 1/18/11 Minutes and record of Hearing (video)	2/25/11
Email, ET to AA: Confirmation that she will remain on Subcommittee	2/28/11
Hearing Outline for Subcommittee	3/1/11
Hearing Notice – DRI Hearing	3/1/11
Minutes – DRI Hearing	3/1/11
Email, AA to Paul Ammann (PA), Copy of Hearing Outline	3/1/11
Letter, AA to GM, Deems DRI application substantially complete	3/1/11
Staff Report Power Point – Copy of Overview	3/1/11
Staff Report Power Point – Copy of Water Resources Comments	3/1/11
Hearing Sign In Sheet	3/1/11
Email, AA to GM, Request for copies of PowerPoints given by Town, Dr. Weiskel, and Mr. Dudley at 3/1/11 hearing	3/2/11
Email, AA to Susan Leven, Transmit copy of one Commission staff PowerPoint presentation	3/2/11
Email, AA to PA, Acknowledges receipt of his request for copies of PowerPoint presentations	3/2/11
Email, Gail Hanley, Commission Clerk, to Orleans, Brewster and Eastham Town Clerks, Hearing Notice for continued procedural hearing	3/2/11

Email, AA to PA, Correct inaccurate date in prior Email: Continued hearing will be on 3/15/11; Procedural Only	3/2/11
Email, Heather McElroy (HM) to AA: Correct inaccuracy in staff PowerPoint concerning Natural Heritage and Endangered Species program comments to date	3/4/11
Email, AA to GM: Transmittal of the 2 Commission staff PowerPoints from 3/1/11 hearing	3/4/11
Email, AA to Susan Leven: Transmittal of second (Water Resources) staff PowerPoint from 3/1/11 hearing	3/4/11
Email, AA to PA, Follow up on request for copies of Commission staff and Town Power Points used at 3/1/11 hearing	3/7/11
Letter, AA to PA, with CD: Copies of Commission Power Points and those given by Town, Brian Dudley (DEP), and Dr. Wieskel at 3/1/11 hearing	3/8/11
Email, HM to AA: Correct inaccuracy in 2/22/11 Staff Report on open space issue – Not required for Town projects	3/10/11
Email, AA to PA: Copies of Power Points being sent by mail on CD	3/11/11
Hearing Notice – Continued Hearing on 3/15/11 – Procedural only	3/15/11
Minutes – Hearing Officer	3/15/11
Memo, AA to Subcommittee: Information submitted for the record	3/16/11
Staff Report (Summary and update of 2/22/11 staff report)	3/16/11
Email, Anne Reynolds, GIS Dept. Manager to PA: Population density mapping	3/16/11
Email with attachment, AA to GM: Copy of March 16, 2011 staff report	3/21/11
Email, AA to Nello Trevisan: Receipt of Email	3/22/11
Copy of MEP Linked Watershed Embayment Model – Framework for Public Comment (Included in record by Tom Cambareri (TC))	3/22/11
Email, AA to Gail Hanley (GH): Add VR to list to receive hearing notices	3/22/11
Email, AA to VR: Confirm receipt of her 3/22/11 Email and comments	3/22/11
Email, AA to VR: Clarify that 3/23/11 is public meeting not hearing	3/23/11
Meeting Notice – Subcommittee Meeting	3/23/11
Memo, AA to Subcommittee: Materials submitted for the record – 3/21/11 Email and comments from Nello Trevisan; 3/21/11 Email and BLOG from MF; 3/22/11 Email and comments from VR; 3/17/11 Technical Memo from Edward Eichner, SMAST; 3/14/11 public comment draft of MEP Linked Model (Received by TC on 3/22/11)	3/23/11
Subcommittee Meeting Outline	3/23/11
Color Slides, Copy, Used by TC at 3/23/11 Subcommittee meeting	3/23/11
Minutes – Subcommittee Meeting	3/23/11
Email, AA to GH: Update of Subcommittee membership, next steps	3/24/11
Email, GH to Town Clerks: Posting continued hearing and meeting	3/24/11
Email, AA to GM: Copy of information submitted for the record to date	3/24/11
Email, AA to VR: Copy of slides used by TC at Subcommittee meeting; Subcommittee meeting on 4/11/11 and hearing on 4/14/11	3/24/11
Email, AA to GM: Clarify impacts to coastal resources from sewer line construction	3/29/11
Hearing Notice – Procedural Only	3/31/11
Minutes – Hearing Officer	3/31/11
Email, AA to GM: Update on Subcommittee meeting and hearing	4/4/11

Email, GH to Town Clerks in Orleans, Brewster, Eastham – Updated posting of notice for cancelled meeting and continued hearing	4/4/11
Email with attachments, Heather McElroy (HM) to Holly Trevisan: Information on Box Turtles and NHES program	4/6/11
Email, HM to Holly Trevisan (HT): Box Turtles and NHES program	4/7/11
Email, AA to HT: Clarify location of next hearing (on 4/14/11)	4/7/11
Memo, Andy Koziol: Transportation Level of Service analysis	4/7/11
Meeting Notice – Subcommittee meeting (cancelled)	4/11/11
Email, AA to PA: Receipt of comment letter; 4/14/11 hearing location	4/8/11
Email, AA to GM: Copies of materials in record 3/23/11 to 4/8/11	4/8/11
Staff Report	4/8/11
Email, AA to GM: Copies of 4/8/11 staff report	4/8/11
Memo and attachments, AA to Subcommittee: staff report; draft 3/23/11 minutes; 3/23/11 staff slides; 4/6/11 and 4/7/11 Emails from HM to HT on Box Turtles; 4/7/11 Transportation Memo; 3/29/11 & 3/31/11 letters from GM; 3/23/11 Email from James Gallagher; Two 4/6/11 Emails from HT to HM on Box Turtles; and 4/8/11 Email and letter from PA	4/8/11
Hearing Notice – Continued public hearing	4/14/11
Email, AA to GM: Copy of letter from David Farquhar	4/14/11
Copy of Water Resources Staff Report Power Point slides	4/14/11
Copy of Staff Report Power Point Slides	4/14/11
Hearing Outline	4/14/11
Minutes – Continued public hearing	4/14/11
Hearing Sign In Sheet	4/14/11
Email, GH to Brewster, Eastham and Orleans Town Clerks, Notices for 4/28/11 continued hearing and 5/24/11 meeting	4/20/11
Email, Jessica Wielgus, Commission Counsel, to GM: Hearing process	4/21/11
Email, AA to GM: Request for letter from Ms. Fulcher, Orleans Board of Selectmen (not sent as part of 4/21/11 Email)	4/25/11
Email, AA to GM: Follow up on GM request for materials submitted and audio file of 4/14/11 Subcommittee hearing	4/26/11
Email, AA to Sue Leven, Brewster Town Planner: Response to her inquiry for draft decision	4/26/11
Phone Log, AA to Beverly Carney: Appeal of Commission decisions	4/27/11
Meeting Notice – Subcommittee Meeting	4/28/11
Email, AA to GM: Response to his request to be kept informed of Subcommittee questions	4/28/11
Email, AA to GM: Follow up to his request for materials from record	4/28/11
Email, AA to Susan Broderick, Brewster: Acknowledge receipt of letter by Email from Brewster Town Administrator	4/28/11
Email, AA to GM: Forward copy of letter from Brewster Town Admin.	4/28/11
Email, Thomas Cambareri to Paul Neidzwiecki: Copies of Power Point presentations related to assimilative capacity of Namskaket Marsh	4/28/11
Email, AA to Susan Broderick: Public officials welcome to attend meetings and hearings	4/28/11
Letter, AA to GM: Copies of materials from the record and audio file of 4/14/11 hearing (on CD) (By hand)	4/28/11

Meeting Outline	4/28/11
Minutes – Subcommittee meeting	4/28/11
Memo, AA to Subcommittee: Copies of materials submitted at 4/14/11 hearing; 4/20/11 letter from Ms. Fulcher and 4/27/11 Email from MF (distributed at meeting)	4/28/11
Email, AA to GM: Follow up to materials provided by hand on 4/28/11	4/29/11
Email, AA to Sue Leven, w/attachs: Follow up to her request for copies of Commission staff reports	4/29/11
Phone Log, AA to VR: Follow up to discussion at 4/14/11 hearing	4/29/11
Letter, AA to Sue Leven: Copies of Commission staff Power Points	
Email, GH to Brewster, Eastham, Orleans Town Clerks – Notices	5/13/11
Email, AA to Sue Leven, Sarah Raposa, Sheila Vanderhoef on continued hearing and meeting on 5/24/11	5/17/11
Email, AA to Administrative Staff at Eastham Town Hall- Hearing Notice for 5/24/11	5/18/11
Email, AA to GM and Commission staff: Subcommittee still in deliberations, so no DRI decision; hearing on 5/24/11 for testimony; Hearing and record may close 5/24/11 or 5/27/11	5/18/11
Phone Log, AA to BC: Returned her phone call of 5/17/11 about hearing	5/18/11
Email, AA to Commission staff: Copy of PA's Email of 5/19/11	5/19/11
Email, AA to GM: Copy of PA's Email of 5/19/11	5/19/11
Email, AA to PA: Receipt of his Email and attachment	5/19/11
Email, AA to GM: Response to his Email about next steps in process	5/20/11
Cover Memo, AA to Subcommittee – Copies of materials from the record: Draft 4/14/11 and 4/28/11 Minutes; 5/12/11 Brewster proposal; 5/17/11 Email from AA to Sue Leven, Sheila Vanderhoef; 5/18/11 Email from GM on DRI decision; 5/18/11 Email from AA to GM; 5/19/11 letter from Paul Ammann, Edward Daly and Jeffery Eagles; 5/18/11 letter from Peter Norton, Brewster BOS Chair; 5/20/11 Email from GM on process; 5/20/11 Email from AA to GM on process; 5/20/11 Email and letter from GM on response to Paul Ammann including Article #4 from Town Meeting; 5/24/11 Email from GM with response to Paul Amman; 5/24/11 Email from Beverly Carney	5/24/11
Hearing Notice – Continued hearing	5/24/11
Continued Public Hearing Minutes	5/24/11
Meeting Notice	5/24/11
Email, AA to Beverly Carney: Receipt of her Email of 5/24/11	5/24/11
Email, AA to GM: Copy of 5/24/11 Email from Beverly Carney	5/24/11
Email, AA to GM, Sue Leven and Sheila Vanderhoef: Notice that hearing period and record will close on 5/27/11	5/24/11
Email, AA to Sue Leven: Please clarify Email on 5/18/11 letter	5/24/11
Hearing Outline	5/24/11
Sample Motions on Findings for Review and Approval	5/24/11
Hearing Sign-In Sheet	5/24/11
Email, AA to Commission staff: Copy of 5/25/11 Email/letter from GM	5/25/11
Email, AA to GM: Receipt of 5/25/11 Email and letter	5/25/11
Email, AA to GM: Acknowledge request for copies of materials submitted at 5/24/11 hearing and until record is closed	5/25/11

Email, GH to Brewster, Eastham and Orleans Clerks: Meeting Notice	5/25/11
Email, AA to Susan Leven, Sheila Vanderhoeff, Sarah Raposa and GM: Subcommittee to hold meeting on 6/9/11 at 1:00 PM	5/25/11
Email, AA to PA: Receipt of Email and PDF attachments	5/27/11
Email, AA to Carol Spade: Receipt of 5/26/11 Brewster Conservation Commission letter	5/27/11
Memo, AA to Subcommittee: Materials submitted since 5/24/11	6/2/11
Meeting Notice	6/9/11
Minutes – Subcommittee meeting	6/15/11
Email, Len Short to AA: Copy of Email from MF (10:10 AM)	6/29/11
Email, Len Short to AA: Copy of Email from MF (10:43 AM)	6/29/11
Email, Len Short to MF (4:31 PM)	6/29/11
Draft written decision	7/1/11
Signed Extension Agreement	7/7/11
Letter, Attorney Elizabeth Enos, to MF, public records request, copy of draft 7/1/11 written decision	7/8/11
Email, Len Short, Orleans Commission member, to AA; Transmission of Email from Augusta McKusick	7/14/11
Email, Len Short to Augusta McKusick; About her 7/14/11 Email	7/14/11
Email, AA to MF; No Subcommittee meeting on 7/19/11	7/15/11
Hearing Notice	7/21/11
Meeting Outline for 7/21/11 Commission meeting	7/21/11
Signed Extension Agreement	9/15/11
Memo and attachments, AA to Subcommittee: Copy of draft decision, copy of draft 6/9/11 and 7/7/11 Minutes	9/21/11
Draft written decision	9/16/11
Meeting Outline	9/27/11
Meeting sign in sheet	9/27/11]
Minutes – Subcommittee meeting	9/27/11
Email, KS to GM and others – Draft written decision	10/3/11
Email, KS to Subcommittee – Draft written decision and meeting	10/3/11
Draft written decision	10/7/11
Meeting Outline	10/7/11
Minutes – Subcommittee meeting	10/7/11
Email, KS to GM and others – Copy of draft decision	10/7/11
Commission Staff PowerPoint of draft decision	10/13/11
Materials from Applicant	***Date Received***
Draft CWMP, Prepared by Wright-Pierce, dated October 2008	2/5/09
Draft CWMP, Prepared by Wright-Pierce, Expanded ENF/Single EIR and Joint Review Application	4/29/09
Draft CWMP, Prepared by Wright-Pierce (WP), dated April 2009 (Paper copy and CD)	5/1/09
Transmittal memo, Heather Merriman, WP, copy of draft CWMP/Expanded ENF and CD	5/1/09
Abutters List (Surrounding Tri-Town site)	5/19/09
Letter, John Kelly, Town Administrator, to Secretary Bowles, clarification of draft CWMP and Expanded ENF	6/22/09

Email, George Meservey (GM), to AA, DRI process	2/2/10
Email, GM to AA, Acknowledgement of response on DRI process	2/3/10
Printout, Orleans CWMP, Flows at Tri-Town Site	February 2010
Cover letter, Michael Giggey (MG), WP, to Secretary Bowles, Response to comments on Expanded ENF	12/13/10
Email, Town Clerk, Hearing Notice has been posted	12/28/10
Email, GM to AA, Request for list of Subcommittee members	1/6/11
Color PowerPoint Slides (93), Town's Presentation at 1/18/11 hearing	1/18/11
Email, GM to AA, Will respond to issues raised	1/19/11
Email, GM to AA, Reservation of room at Town Hall on 3/1/11	2/7/11
Letter, GM to Paul Niedzwiecki, CWMP consistency with local bylaws and Local Comprehensive Plan (by Email)	2/11/11
Email, GM to AA, Speakers at 3/1/11 hearing as part of Town's presentation	2/28/11
CD containing video of Joint Commission/MEPA hearing on 1/18/11	2/28/11
Letter, GM to Roger Putnam, Subcommittee Chair, Response to comment received at 1/18/11 hearing	3/1/11
Color Power Point Slides, Wright-Pierce, Given as part of Town's presentation at 3/1/11 hearing	3/8/11
Color PowerPoint Slides, Dr. Wieskel, USGS, Given as part of Town's presentation at 3/1/11 hearing	3/8/11
Email, GM to AA: Clarification concerning Power Point slide used by Brian Dudley (DEP) at 3/1/11 hearing	3/8/11
Email, GM to AA: Concerns about open space requirements	3/9/11
Email, GM to HM: Concerns about open space requirements resolved	3/10/11
Email, GM to AA: Comment letter, with attachments: Response to comments and questions raised at 3/1/11 hearing	3/11/11
Letter, GM to AA: Hard copy of letter sent by Email on 3/11/11	3/14/11
Email, GM to AA: Information on sewers in public and private roads	3/15/11
Email, GM to AA: Request for copies of information submitted by public and Towns, others, to date	3/24/11
Email, GM to AA: Letter on private roads post sewer construction	3/29/11
Letter: GM to Roger Putnam: Hard copy of 3/29/11 Email	3/30/11
Email, GM to AA: Memo on impacts to coastal resources	3/31/11
Letter, GM to Roger Putnam: Hard copy of 3/31/11 Email	4/1/11
Email, GM to AA: Question on Subcommittee meeting	4/4/11
Letter, Ms. Fulcher, Orleans Board of Selectmen (BOS) to Subcommittee	4/14/11
Email, GM to KS: Letter from Ms. Fulcher, Orleans BOS	4/21/11
Email, GM to AA: Request for Subcommittee Minutes of 1/18/11, 3/1/11 and 3/23/11	4/21/11
Email, GM to AA: Letter from Ms. Fulcher, Orleans BOS (not sent as part of 4/21/11)	4/25/11
Letter, Ms. Fulcher, Orleans BOS (Also sent by Email 4/25/11)	4/25/11
Statement of Cooperative Intent with Town of Brewster (2 pages)	5/12/11
Email, GM to AA: DRI decision drafted and agenda for 5/24/11 hearing	5/18/11
Email, GM to TC: Study of alternate wastewater treatment systems per	5/20/11

Town Meeting vote and copy of Article #4	
Email, GM to AA: Next steps in review process	5/20/11
Email, GM to AA, with attachment: Response to comments from Paul Amman, Edward Daly and Jeffery Eagles	5/24/11
Letter, GM (by hand at hearing): Copy of response to Paul Amman, Daly, Eagles	5/24/11
Email, GM to AA, with attachment: Letter from Margie Fulcher as final comments	5/25/11
Letter, David Dunford, Orleans Selectman	5/26/11
Email and attached draft decision, GM to PD and TC: Town's comments on draft decision	9/12/11
Materials from Local, State, Federal Agencies	***Date Received***
Letter, Massachusetts Historical Commission (MHC), reconnaissance survey requested, and further review as project proceeds	5/18/09
Secretary of EOEEA, Certificate on Expanded ENF	7/10/09
Letter, MHC, further review as project proceeds	12/23/10
Note, on Snow Library stationary, Confirm delivery by Commission staff of CWMP to Library	1/11/11
Letter, to Secretary Bowles and Paul Niedzwiecki, from Patricia Hughes, Chair, Brewster Comprehensive Wastewater Planning Committee	1/18/11
Letter, to Secretary Sullivan and Paul Niedzwiecki, from Arnold Henson, Chair, Orleans Conservation Commission	1/18/11
Letter, Sims McGrath, Vice Chair, Orleans Board of Selectmen, Comments on CWMP	1/18/11
Email and Letter, with attachments, to Secretary Sullivan and Paul Niedzwiecki, from Jane Crowley, Eastham Health Agent on behalf of Selectmen	1/24/11 Email received 1/21/11
Secretary of EOEEA, Certificate on CWMP/Single Final EIR	1/28/11
Email, Susan Leven, Brewster Town Planner, Request for Staff Report	2/15/11
Letter, Linde MacLeod, President, Orleans Conservation Trust	3/1/11
Email, Susan Leven, Request for copies of Commission staff's PowerPoint presentations used at 3/1/11 hearing	3/2/11
Letter, Edward Lewis, Chair, Brewster Board of Selectmen, to Margie Fulcher, Chair, Orleans Board of Selectmen	3/7/11
Edward Eichner, Senior Water Scientist, to TC: Email and Technical Memo – Namskaket Marsh Estuary Watershed	3/17/11
Email, Sue Leven, Brewster Town Planner, to AA: Request for draft decision	4/26/11
Email, Susan Broderick, Administrative Assistant, Brewster Town Administrator, with attachment: Copy of letter from Brewster Town Administrator	4/28/11
Email, Town of Brewster, with attachment: 5/18/11 letter on CWMP addressed to Paul Niedzwiecki	5/19/11
Email, Sue Leven to AA: Correction to Town's letter of 5/18/11	5/24/11
Email, Sue Leven to AA: Clarification of correction to Town's 5/18/11 letter	5/24/11
Letter, Stephen McKenna, Chair, Brewster Conservation Commission	5/27/11
Letter, Peter Norton, Chair, Brewster Selectmen	8/16/11
Materials from General Public	***Date Received***

Letter, with attachments, from Mary Hartley to Secretary Bowles	11/10/09
Letter, with attachments, from Mary Hartley to Secretary Bowles	4/7/10
Email, from Augusta McKusick	1/11/11
Email, from Carole Ridley, to AA, NZ and others, Comment letter	1/12/11
Email, from Michael C. Farber (MF), to PD and others	1/13/11
Email, from Fran Meaney to PD and others	1/13/11
Email, from MF to KS and others, request postponement of hearing	1/13/11
Email, from Kevin Cassidy to PD and others, postponement of hearing	1/13/11
Email, from MF to PD and others	1/13/11
Email, from MF to PD and others	1/13/11
Email, from MF to PD and others	1/18/11
Email, from MF to PD and others	1/18/11
Email, from MF to PD and others	1/18/11
Email, from MF to GM, PD, KS and others	1/18/11
Email, from MF to PD, NZ and others	1/18/11
Copy, provided by Vicky Reis, Black and white printout of slides from 2/15/05 presentation by Peter K. Weiskel, USGS	1/18/11
Copy, Color brochure of *Orenco's Effluent Sewers* and a 11/23/09 My View Article by Gary P. Clifton, from *Cape Cod Times*	1/18/11
Letter, Carolyn Kennedy, Comments on CWMP	1/18/11
Second Letter, Carolyn Kennedy, Orleans Pond Coalition, to Secretary Sullivan and Paul Niedzwiecki	1/18/11
Letter, Douglas Pluciennik, Comments on CWMP	1/18/11
Second Letter, Douglas Pluciennik, Comments on CWMP	1/18/11
Letter, Ben Buck, Comments on CWMP	1/18/11
Letter, David Farquhar, Comments on CWMP	1/18/11
Letter, Beverly Carney (BC), Comments on CWMP	1/18/11
Letter, Alan McClennen, Jr., Comments on CWMP	1/18/11
Second Letter, Alan McClennen, Jr., Comments on CWMP	1/18/11
Email, KS to MF, Legal Notice of MEPA Hearing	1/18/11
Email, Kevin Cassidy, to AA, Comments on CWMP	1/19/11
Email, MF to NZ and KS, Contacting Mary Hartley	1/19/11
Email, Augusta McKusick, to Glenn Cannon, Schedule for next hearing	1/24/11
Letter, Brian and Judy Embleton, to Secretary Sullivan	1/24/11
Email, with attachments, Paul Ammann (PA) to TC, Comments on CMWP	2/1/11
CD, Copy of Paul Ammann's comments on CWMP	2/1/11
Email, MF to Vicky Reis and others, Groundwater Protection Fund	2/7/11
Email, MF to GM and KS, Public records request	2/8/11
Email and color attachments, MF to AA: CapeCodLiving BLOG/Cockle Cove Creek	2/8/11
Email, MF to Various, CapeCodLiving BLOG/Cape Cod Groundwater Protection Fund	2/20/11
Email, Paul Schwartz, National Policy Coordinator, Clean Water Action, to MF, Namskaket Marsh	2/22/11
Email, MF to Paul Schwartz, Namskaket Marsh	2/22/11

Email, MF to Various, MA Conservation Foundation / V Coalition for Buzzards Bay	2/22/11
Packet of Materials, from Mary Hartley, Groundwater Protection Fund	3/1/11
Copy, Color brochure of *Orenco's Effluent Sewers* and a 11/23/09 My View Article by Gary P. Clifton, from *Cape Cod Times*	3/1/11
Letter, Beverly Carney, Comments on CMWP	3/1/11
Letter, Jeffrey Eagles, Comments on CWMP	3/1/11
Letter, Len Short, Comments on CWMP	3/1/11
Letter, Carolyn Kennedy, Comments on CWMP	3/1/11
Letter with attachments, Vicky Reis, Comments on CWMP and ACEC	3/1/11
Letter, Douglas Pluciennik, Comments on CWMP, ACEC, SMAST	3/1/11
Letter, Nello Trevisan, Comments on CWMP	3/1/11
Letter with attachments, Nello and Holly Trevisan, Information on George D. Hofe Memorial Conservation Area	3/1/11
Email, PA to AA and others, Request for copies of Commission staff PowerPoint presentations and Town's PowerPoint presentations given at 3/1/11 hearing	3/2/11
Email, PA to AA: Acknowledges hearing date is 3/15/11 and hearing will be procedural only	3/3/11
Email, PA to AA: Response to 3/7/11 Email concerning copies of Power Point presentations	3/11/11
Email, PA to AA: Received CD with Power Points by mail	3/11/11
Email with attachment, Pete and Ellie Johnson – Holly Trevisan's letter on the George D. Hofe Trust (Sent to Commission Member Taylor)	3/14/11
Email, with attachment, Mark Robinson – Letter from Linde MacLeod, Orleans Conservation Trust dated 3/1/11) (Sent to Commission Member Elizabeth Taylor)	3/14/11
Email, Fran McClennen to KS: File Review	3/14/11
Letter, Ben Buck, Comments on Orleans CWMP	3/15/11
Email, PA to AA: Population density maps	3/15/11
Email, PA to Anne Reynolds: Receipt of information on population density maps	3/17/11
Email, MF to AA and KS: Cape Cod Living – BLOG – *Groundwater Protection Fund Going Old Salt on Namskaket*	3/21/11
Email, Nello Trevisan to AA: Comments on CWMP	3/21/11
Email, Vicky Reis (VR) to AA: Comments on CWMP (Includes comments made at 3/1/11 public hearing)	3/22/11
Email, VR to AA: Question on public *hearing* on 3/23/11 (3/23/11 is a public meeting)	3/22/11
Email, VR to AA: Follow up of telephone conversation with AA	3/23/11
Email, Holly Trevisan (HT), to HM: Box Turtles and NHES program (*attached to HM 4/6/11 reply*)	4/6/11
Email, HT to HM: Box Turtles	4/6/11
Email, HT to AA: Confirm understands next hearing is on 4/14/11	4/7/11
Email and attachment, PA to AA: Comment letter on staff citations of the June 2009 Woods Hole Group (WHG) report	4/8/11
Letter, PA to TC: Copy of letter on WHG report (also by Email 4/8/11)	4/8/11
Letter, DF to Subcommittee: Comment letter	4/14/11

Letter, PA to Subcommittee: Comment letter	4/14/11
Copy of Comments presented at hearing: Chet Crabtree	4/14/11
Copy of Comments presented at hearing: Jeffrey Eagles	4/14/11
Copy of Comments presented at hearing: Carolyn Kennedy	4/14/11
Copy of Comments presented at hearing: Jane Corlette	4/14/11
Copy of Comments presented at hearing: Len Short	4/14/11
Copy of Comments presented at hearing: Judith Bruce	4/14/11
Four (4) color photographs from Steve Ellis	4/14/11
VR to Subcommittee: Copies of information including 10/10/08 *Cape Codder* article; Census Bureau fact sheet on Orleans; Tidal Atlas information; 7/30/09 letter and attachments to Michael Farber from Daniel McKierman, Massachusetts Division of Marine Fisheries; ENF form for Project # 13833, Little Namskaket Creek and US Wildlife Service summary sheet on Coastal Wetland Conservation Projects for Fiscal Year 2002 (culvert on Namskaket Creek)	4/14/11
Email, MF to AA and others: Groundwater Protection Fund Alert	4/27/11
Email, VR to AA: Clarified that she wanted Minutes of 4/14/11 hearing	5/12/11
Email, PA, Edward Daly, Jeffery Eagles, with attachment: Comments	5/19/11
Email, Beverly Carney to AA: Comments on project	5/24/11
Letter, Nello Trevisan: Comments on project	5/24/11
Letter, David Farquhar: Comments on project	5/24/11
Letter, Edward Daly: Comments on project	5/24/11
Letter, Alan McClennen: Comments on project	5/24/11
Packet of information, VR: 5/09 Phase 8 supplemental site investigations, site 241 from CWMP; 1/19/01 letter to Secretary Sullivan of EOEEA with its attachments; 6/2/10 letter from Orleans Board of Selectmen to Barnstable County Commissioners on MEP Methodology Section 11.2.2 of CWMP - Public consultation process – Wright-Pierce; April 2009 draft, Table 7-5, treatment plant sites, Wright-Pierce; May 2008 draft, Section 5.12-Suitablility of treatment facility sites, Wright-Pierce; From 2008 Orleans Town Report – Town Meeting Article 9 – Orleans CWMP; *Cape Codder*, 10/10/08 article, *Draft Wastewater Plan Leads Warrant; Cape Cod Times*, 5/10/11 article, *Large Majority Backs New Study of Sewer Systems*; Table 2-2, CWMP, Current Wastewater Flows, Wright-Pierce; Listing of Massachusetts Areas of Critical Environmental Concern, June 2009; Summer, 2003 – Description of Inner Cape Cod Bay ACEC; Town of Orleans: Town Map, Chart of Site Characteristics, Slides 1-7; Cape Cod Atlas of Tidally Restricted Marshes (5 pages); Three pages of color GOOGLE maps showing Tri-Town site; 4/3/09 LEC color Aerial Orthophoto of Tri-Town site; Color Aerial Orthophoto showing Box Turtle habitat; Orleans CWMP, color figures 1, 2, 3, 4, 11-2 showing existing and proposed treatment facilities; Three pages of color photographs of views of Tri-Town site taken 2/11/09; Site locus of Tri-Town site, August 2005; USGS File Report, 95-290: *A Nitrogen-Rich Septage Effluent Plume in a Glacial Aquifer, Cape Cod, MA, February 1990 through December 1992*, Leslie DeSimone et. Al., 3/5/10 Memo, Attorney Michael D. Ford, to John F. Kelly, Orleans Town Administrator; 7/7/88 letter, MA Division of Marine Fisheries, to Orleans Board of Selectmen, closures of shellfish beds; 7/30/09 letter,	5/24/11

Daniel J. McKierman, Division of Marine Fisheries, to David Farquhar; Orleans CWMP, Figure 14, Site 241, Particle Tracks – Wright Pierce; Comments from Nello Trevisan on George D. Hofe Memorial Trust Conservation Area; Newspaper article, Nello Trevisan, MY VIEW, *Sewage Plant Imperils Two Marshes;* Large size color GOOGLE map showing Tri-Town site	
Letter, with attachments, Marty Hartley: Comments on project	5/26/11
Letter, with attachments, VR: Article, *Orleans Oracle* 11/15/90; Article, *Cape Codder*, 11/27/90; Article, *Cape Cod Times* 10/26/90; Article, *Cape Codder*, 9/18/90; *Orleans Oracle*, Opinion, 11/1/90; Article, *Cape Codder*, 11/27/90; Article, 11/8/90; Article, *Orleans Oracle*, 12/27/90; Article, *Cape Cod Times*, 4/12/97; Article, *Cape Cod Times*, 9/17/90; Article, *Orleans Oracle*, 10/25/90; Article, *The Advocate*, 11/8/90	5/26/11
Letter, with attachments, Allan McClennen: Comments on project	5/26/11
Email with attachmts, PA to AA: Letters from himself & Jeffrey Eagles	5/27/11
Email, MF to various people: Groundwater Protection Fund – New Alert	6/27/11
Email, MF to various people: Public Records Request for USGS Test Results	6/28/11
Email, MF to various people: Public Records Request	7/12/11
Letter, Pam Curren, Objection to project	7/14/11
Letter, Ed DeWitt, Executive Director, APCC	10/6/11
Beverly Carney	10/11/11
Jon Fuller	10/13/11

TESTIMONY

March 1, 2011 Subcommittee DRI Hearing

The Commission Subcommittee held a public hearing for the purpose of receiving comments on Orleans Comprehensive Wastewater Management Plan (CWMP) as a Development of Regional Impact (DRI). The Subcommittee heard presentations on the CWMP by the Commission staff, Town staff, and the Town's consultants. The Subcommittee heard comments and questions on the CWMP from persons who attended the hearing. The Subcommittee approved the draft Minutes of the January 18, 2011 joint hearing with MEPA as presented. The Subcommittee voted to continue the hearing to March 15, 2011 at 10:00 AM at the Commission's office in Barnstable for procedural purposes.

Mr. Meservey discussed the process of developing the Orleans CWMP and the public involvement over the past ten years and used a series of PowerPoint slides to illustrate his points. Mr. Meservey handed out a written response to comments made at the January 18th hearing to the subcommittee for the record, as well as an engineering evaluation of the nitrogen loading at the Nanskaket Marsh system in response to a question brought up by Mr. Taylor. Mr. Meservey then invited Mike Giggey of Wright-Pierce to make a presentation on the overall CWMP.

Mr. Giggey began his presentation by reviewing the CWMP process and the EENF and S/FEIR review process and stating that the driving force is to reduce nitrogen loading in embayments and eliminate as many as 2800 septic systems while addressing sanitary needs, pond protection, water supply protection and provide an allowance for affordable housing. Mr. Giggey discussed the process by which the current plan was chose and noted that it was most

favored by 70% of respondents. He discussed the benefits of this plan and what it entails. Mr. Giggey provided a time line for completion and noted the environmental factors involved and the estimated cost of completing all six phases, and stated that using a Tri-Town site will save the Town's money. Mr. Giggey also noted that the MEPA process has been completed since the last public hearing and on January 28, 2011 the EOEA secretary found that the Orleans Comprehensive Management Plan properly and adequately complies with the Massachusetts Environmental Policy Act. He stated that comments were made by agencies that are deeply involved with the environmental issues that impact Orleans such as Marine Fisheries, Coastal Zone Management, and the Department of Environmental Protection. He stated that he wanted to address some of the comments that were made. He referred to a comment relating to STEP systems and confirmed that the town could save money by using these systems and they will be analyzed and to the extent that they make sense will be utilized at certain sites. He then noted that the Town did thoroughly look at decentralized options, but it would cost about 40% more than the plan that was chosen and it did not have the support of the public that participated in the process. It was also confirmed by an engineering report that the decentralized options were neither feasible nor cost-effective. Mr. Giggey stated that at the last hearing he also heard comments about the science, and whether there was adequate science to support the plan. He stated that a recognized expert was hired to look at the plan and the CWP is based on the "science of record." It is the accepted science across the Cape, well documented, and the Town's independent consultant has approved the plan. He stated that the Applicant is asking for DRI review of the plan, not the science behind it. He went on to address a comment dealing with the improvement of water quality in Pleasant Bay. He stated that the Pleasant Bay Alliance has looked at ten years of data in Pleasant Bay and the report stated that most stations showed no statistically significant change in water quality in most stations and in headquarters. He noted that DEP has looked at the 2007 breach and warned not to rely on it because it would not be around for long. Mr. Giggey then discussed a question relating to the removal of wastewater from one watershed and adding it to another. He stated that today there is approximately 44 million gpd of recharge. He noted that as a result of the project, Pleasant Bay will have a reduction in recharge by about a quarter of a million gallons per day. There will also be a reduction in the Nauset Watershed, but an increase in Cape Cod Bay, and the increase was what was questioned in the last hearing. The increase will be about 6%. He noted that the year to year variations in recharge are much more drastic than the variation that results from this plan. He noted that in 1950 the recharge in the watershed stayed there because there was no town water system.

Mr. Giggey reviewed the four different ways to characterize the Tri-Town site in respect to effluent disposal and showed slides relating to the mounding under current and proposed conditions and what they indicate. Mr. Giggey acknowledged that with the proposed upgrades to the Tri-Town site, the amount of flow would increase, but the nitrogen loading from the flow would decrease. Mr. Giggey said the project impacts to Namskaket Marsh used in the CWMP are conservative relative to the MEP's assumptions. He said the marsh has adequate capacity to assimilate the annual nitrogen loads expected with the proposed project. He said the MEP reports indicate the marsh has the ability to assimilate 37,000 pounds per year, and the CWMP project represents a 13,700 pound per year load with expected growth. He noted that septic systems create nitrogen plumes and that the discharge from a wastewater treatment plant would be lower than that from a septic system. Mr. Giggey said the creek channels in the marsh are where the majority of the nitrogen absorption occurs.

Dr. Peter Wieskel, Associate Director, MA/RI US Geological Survey, presented a PowerPoint presentation. He reviewed the USGS's involvement in hydrogeologic investigations at the Tri-Town site from 1989 to the present. He noted this included tracking the development of a

nitrogen plume, an ecology study in Namskaket Marsh and baseline water quality data in Namskaket Creek, sampling in 2003 of the aquifer below the marsh, and resumption of water quality sampling in 2004 and again in 2010. He used a series of slides representing the marsh cross-section to describe the plume's interaction with the marsh. He said the maximum plume concentration was approximately 15 mg/liter versus a septic system at 30 mg/liter. He said there are four possible routes from plume discharge, and discussed the relative likelihood that the plume would discharge in each of these areas in the marsh. Dr. Wieskel said the most likely flow path for the plume is in the creek zone or deep flowpath. He said this is based on the relative geology, salinity levels (which are an indication of groundwater discharge), and the flowpath of the plume. Dr. Wieskel showed slides indicating locations of potential additional monitoring sites, which are still subject to discussion and indicated some sites would include sampling in the creek bottoms and another set of wells further downgradient along public roads. He noted sampling had started at three sites in the creek (Sites A, B, E) during ebb tide, looking at nitrogen loading. He compared current samples to those taken in 1993-1996, and noted the data sets show the same relative nitrogen concentrations which indicates no impact from the plume.

Brian Dudley, MA Department of Environmental Protection (DEP), used a single Power Point slide (#71 in Mr. Giggey's presentation) to describe the DEP's involvement in the CWMP and groundwater discharge permit program. He said the state's groundwater discharge program would involve a hydrogeological evaluation, a review of down-gradient receptors, a review of plant design plans, and would include public comment and a monitoring plan.

Ms. Andrea Adams, Senior Regulatory Planner for the Commission provided an overview of the project and discussed the Commission's jurisdiction and Commission staff analysis. She reviewed each section of the Regional Policy Plan, as covered in the Commission's Staff Report, beginning with Natural Resources. She noted a "no take" letter from the Natural Heritage and Endangered Species Program and that Natural Heritage may require a Conservation Management Plan which could includes ways to address the open space requirements of the Regional Policy Plan ("RPP"). She emphasized the benefits of reuse of the Tri-Town site and existing disturbed areas and the growth-neutral policy of the CWMP. Ms. Adams noted that the Tri-Town site does not impact coastal resources, but some project components may impact dunes, beaches, and Land Subject to Coastal Storm Flowage (LSCSF), and reviewed a variety of measures to address compliance with Coastal Resources Minimum Performance Standards. Ms. Adams stated that in the area of Heritage Preservation and Community Character, in a letter dated December 20, 2010, the Massachusetts Historical Commission (MHC) determined that the project is unlikely to impact significant archaeological resources at the Tri-Town site. The Town will conduct a survey for archaeological resources at sites selected for Cluster systems and the project will be reviewed by MHC and Old Kings Highway Historic District (OKHHD). Ms. Adams noted that the project is likely to be consistent with RPP Minimum Performance Standards for protection of archeological sites and historic structures and consistent with distinctive areas. In the area of Transportation, Ms. Adams stated that staff estimates a reduction in septage truck trips to the Tri-Town facility once the site is upgraded as stated in the Single/Final EIR, and that the Town should provide estimates of all daily and peak hour trips. Ms. Adams noted the RPP Standards in this area and stated that the Tri-Town plant's driveway should be analyzed to determine if it meets the sight distance standards and the Town should conduct Level of Service at the Tri-Town plant's site drive. Ms. Adams concluded her portion of the presentation by introducing Mr. Tom Cambareri from the Commission's Water Resources staff to discuss Water Resources and the conclusion.

Mr. Tom Cambareri, Hydrologist and Water Resources Program Manager at the Cape Cod Commission provided a PowerPoint presentation in which he reviewed some of the key Minimum Performance Standards in Water Resources, some of the siting issues related to the project, addressed the science involved from the staff's perspective, and highlighted suggested potential conditions of a DRI for the subcommittee's consideration. Mr. Cambareri reviewed the goals of the Water Resources section of the RPP and several Minimum Performance Standards within those goals and the Plan's compliance with these Standards. Facility siting, Mr. Cambareri stated, is one of the most difficult challenges of any CWMP and there is a host of criteria to evaluate the suitability of sites. He reviewed the criteria and the process for selecting suitable sites. He compared the annual flow and annual nitrogen load of the Tri-Town site with the proposed Wastewater Treatment Facility at the initial phases and noted that although the flow increases significantly, the concentration of treatment effluent is less. He also stated that the numbers do not account for hydrogeologic underflow and the assumptions are conservative. Mr. Cambareri stated that the Consultant Model indicates that 70% of effluent flow may discharge into Namskaket Creek but USGS studies indicate a larger percent of effluent flow passes beneath the Marsh to Cape Cod Bay. He then compared the existing and build out loads at Namskaket Creek and noted that the threshold load for Namskaket is 36,925 lbs/yr. He presented a slide demonstrating town contribution to wastewater flow into Namskaket watershed and stated that approximately 58% comes from Brewster, 23% from Orleans residential, and 19% from Orleans commercial.

Mr. Cambareri explained the MEP approach and noted that the science behind it is comprised of watershed delineation, nitrogen loading, hydrodynamic models, ecological conditions, and water quality models. Mr. Cambareri stated that many questions were raised about the science, and Commission staff reviewed the information that was handed to them and looked at the Woods Hole Group Peer Review Report from June 2009 on Pleasant Bay MEP and some of the conclusory points were that MEP is a high quality and necessary endeavor, and the overall modeling approach is well conducted and the hydrodynamic model appears to be reasonably calibrated and verified, and the MEP report for the Orleans portions of Pleasant Bay represent a strong foundation for developing a course of action to develop and comply with site specific TMDL requirements. The core recommendations from the report, Mr. Cambareri stated, are to encourage the Town to prepare for a phased wastewater facilities planning approach with incremental steps for complying with TMDL requirements. Depending upon how the estuarine system responds, future phases or plans for wastewater control could be modified, and Mr. Cambareri stated that this is the essence of an adaptive management approach, which he recommended the Town pursue as part of its overall long term compliance strategy. Mr. Cambareri noted that the regulatory status is that the MEP technical reports have been accepted by DEP and EPA as critical loads and have become the TMDLs which have been adopted by Barnstable County according to the Regional Policy Plan. Mr. Cambareri then concluded his presentation with recommended DRI Conditions for consideration and findings for approval. He summarized the criteria for approval of DRIs according to the Commission's *Enabling Regulations* and noted a letter from George Meservey dated February 11, 2011, stating that the plan is consistent with the local comprehensive plan and development bylaws and that since there are no DCPCs in Orleans, this criterion does not apply.

Mr. Peter Graham asked if it is staff's opinion that the plan is consistent with the Regional Policy Plan.

Ms. Adams stated that Mr. Cambareri had demonstrated areas where the project is consistent and Ms. Adams presentation covered other areas of the Regional Policy Plan. She said that staff's general recommendation is that more information is needed in the areas of Natural

Resources, Open Space, and Transportation, so staff is not yet ready to determine consistency with respect to those issues at this time.

Mr. Cambareri noted that the project would be consistent with Water Resources with appropriate conditions.

Mr. Graham asked that staff provide a list to the subcommittee of issue areas where the project is consistent and where it is not.

Ms. Elizabeth Taylor stated that she did not see any mention in the staff report that the marsh area is an Area of Critical Environmental Concern (ACEC) and that she would like to see that in the report. She also stated that she knows there are some issues with the shellfish beds, and that it's not a nitrogen issue but a fecal coliform or E. coli issue. She said she does not know whether that is from effluent from local septic systems or mammals and birds but that should also be mentioned in the report.

Mr. Putnam asked for comments from Federal, State, Regional and local Officials.

Mr. Sims McGrath, Vice Chairman of the Board of Selectmen for the Town of Orleans, member of the Governing Counsel for the Cape Cod Water Protection Collaborative and a former member of the Planning Board spoke about the Town's CWMP and stated that it relies on adaptive management and allows for unanticipated changes. Mr. McGrath stated that a lot of money has been spent by the Town in eliminating as much uncertainty as possible and that the Town is supporting other CWMP review opportunities. He said that maintaining healthy estuaries is a benefit to all the surrounding communities and that the Town looks forward to reviewing and considering the comments and conditions of the staff report and that the Board hopes that the subcommittee will find that the CWMP meets the criteria for a DRI.

Mr. David Dunford, Orleans Selectman, said he had been the Chairman of the Board of Selectmen when the draft CWMP had been brought before the Town Meeting. He said the final CWMP had a number of uncertainties and the Adaptive Management Plan was key. He said he believed the CWMP benefit was greater than its detriments, but those detriments should be reduced. He said the Subcommittee should consider whether the CWMP would result in the proposed benefits, and that the review by the National Academy of Sciences would be beneficial. Mr. Dunford said the Subcommittee should require ongoing monitoring of Namskaket. He expressed concern that the cost of wastewater management would push middle and low-income residents to locate off Cape. He said the CWMPs proposed use of alternative and innovative systems should be strengthened. Mr. Dunford said Pleasant Bay should be re-tested to account for the new break and suggested the classification of Rock Harbor system and boat basin should be re-evaluated. He suggested its current classification was too restrictive.

Mr. Martin McDonald, Eastham Selectmen, said the project had regional impacts. He said Eastham's problems with wastewater management, including siting of a facility, would not be easily addressed. He paraphrased a previously submitted comment letter. He said a joint system at the Tri-Town plant, which Eastham was currently part of, would be the best option for addressing wastewater treatment in parts of Eastham. He said discussions had begun with the Orleans Board of Selectmen and the potential cost savings from a joint planning effort and joint facility were important. He said he shared Mr. Dunford's concern that the classification of Rock Harbor was too restrictive.

Mr. Putnam asked for public comments, using the signup sheet.

Mr. Len Short said the Orleans Pond Coalition supported Orleans CWMP, and he did as well. He said the plan is well conceived and appropriate and its adaptive management plan is key to addressing impacts to ecosystems. Mr. Short recommended the Subcommittee endorse the CWMP.

Ms. Beverly Carney said she did not support the CWMP with respect to Box Turtle impacts in particular. She expressed a concern that there would be a significant impairment to wildlife and plant habitat. She said the proposed cluster systems would only require local review and may negatively impact Box Turtles. She said she supported the Area of Critical Environmental Concern (ACEC) for Pleasant Bay and the 1989 construction of the Tri-Town plant. Ms. Carney said the CWMP is not sufficiently comprehensive. She said a couple hundred voters at a Town Meeting is not an endorsement of the Town as a whole. Ms. Carney said the adaptive management plan is not adequate and the Tri-Town plant is adequate to address the nitrogen loading concerns, as an existing and efficient technology. She urged the Subcommittee to reject the CWMP.

Ms. Pat Hughes, Chair, Brewster Comprehensive Wastewater Planning Committee, said Brewster supports Orleans CWMP efforts. She said the Town of Brewster supported the ACEC designation for Pleasant Bay. She said Brewster is concerned about the plume from the Tri-Town plant and a more comprehensive effort is needed to characterize the plume. She said the Town welcomes the Commission staff's and DEP staff's efforts in working with Orleans and Brewster to determine the assimilative capacity of Namskaket Marsh and Cape Cod Bay. She said the excess capacity of these systems to absorb nitrogen must be carefully and equitably managed.

Mr. Jeff Eagles said the resignations of himself and other members of Orleans Wastewater Management Design Validation Committee had been misrepresented at the January 18, 2011 hearing. He said the resignations were not related to the State's Open Meeting Law. He said the members resigned because they were not able to carry out the duties they had been assigned because of mis-information and personal attacks on their reputations. Mr. Eagles said the members who had resigned read their letters of resignation into the record of an October 14, 2009 Selectmen's meeting. He said an ad hoc citizens group had been formed after this point and the follow up group had kept the Board of Selectmen informed of its work and had submitted 36 questions to the DEP. He said the citizens group had issued reports in March 2010 and these reports had also been submitted to MEPA through Ms. Mary Hartley. Mr. Eagles said this information had also been submitted to the Commission. He said the MEP focus on nitrogen loading and reduction is too limited and the need is for overall water quality improvement. He said the investment made must improve water quality. He supported Mr. Dunford's comments and said the MEP is unlikely to appropriately address the needed water quality improvements in Rock Harbor and Pleasant Bay. He said a review in needed by the National Academy of Sciences. He cited Chesapeake Bay as an example and said the costs should be reduced and the desired water quality improvement outcome ensured.

Ms. Carolyn Kennedy said she had given a statement at the January 18, 2011 public hearing. She said one of the issues that had not as yet been discussed is bacterial contamination. She said the Town is working diligently to address these issues through the Highway Department, from stormwater runoff, including working with NSTAR, so other entities would also clean up their stormwater sources. She said the CWMP looks at the estuaries and fresh water pond impacts and they continue to show impacts from septic systems. Ms. Kennedy urged the Subcommittee to move the CWMP process forward.

Mr. David Farquar said the problem with Orleans CWMP is that it is not comprehensive enough, and does not examine all of the reasonable alternatives. He said the plan needs to look more at decentralized systems. He noted a petition requesting this was delivered to the Board of Selectmen over a year ago. He said decentralized systems are less expensive than the proposed project. He said the CWMP should not go forward without an MEP report or TMDL for North Inlet or Town Cove. Mr. Farquar said this is an important element of the overall plan. He said there are doubts about the nitrogen removal goals for Pleasant Bay and that the Commission had supported a National Academy of Sciences review. He said more study was needed to justify the overall expense. He said the capital expense for designing a plant in a certain way is not justified if the loads in Pleasant Bay are different.

Ms. Holly Trevisan submitted information for the record on the George D. Hoffe Conservation Area. She said this Conservation Area covers much of Nanskaket Marsh. She used a large map to indicate the Conservation Area which she said is approximately 50 acres in total, mostly marsh, but some upland. She said the purpose of the Conservation Area is to maintain the area, and is coordinated with the Orleans Conservation Trust. She said special monitoring should be put in place to gauge impacts to the marsh from septic systems. She said the RPP Natural Resources/Open Space area requires that adverse impacts to wetlands are to be avoided. She said the Secretary's Certificate on the Single/Final EIR indicates that 67% of the effluent from the Tri-Town plan would discharge to Namskaket and Little Namskaket Marsh. Ms. Trevisan said this constitutes an adverse impact to the marsh and suggested it would also put a damper on further conservation bequests.

Mr. Steve Ellis said he does not support the CWMP or the science it is based on. He said there are too many unanswered questions. He said there were Spade Foot toads in the area, and that the area is archeologically sensitive. He put some materials he said he had found in the area on the bench where the Subcommittee was sitting. Mr. Ellis said there was an active herring run in the area and a clay dam under Sky Meadow, and that the Tri-Town plant's effluent plume would move in response to this dam. He expressed concerns about impacts to shellfish beds and to the herring run and doubt about the veracity of the computer models used as part of the CMWP. Mr. Ellis noted the Orleans DPW was causing stormwater runoff impacts from a pipe that he said he had been told would be blocked off. Mr. Ellis said the costs of the proposed program would drive more homeowners out of Orleans.

Mr. Skip Norgeoi said he worked in marine construction for 35 years. As such, he said he understood contracting. He said the information in the CWMP is not correct and none of the tests are correct because the railroad tracks act as a dike and split the Cape into two pieces hydrologically. He said he is concerned about impacts to wildlife such as turtles and terrapins. He expressed concern about negative impacts to the marsh. He said the Woods Hole Oceanographic Institute had done work to show that the railroad tracks act as a dike or levy and effluent is moving into Town Cove. He expressed concerns about impacts to ponds, particularly from nitrates. He said nitrogen is the basis of the marsh's growth, and for the overall marsh food chain. Mr. Norgeoi said the marsh is archeologically significant. He said dye tests should be done to determine where the Tri-Town plume is going.

Mr. Gary Clinton said Orleans needed to consider decentralized wastewater treatment. He said the Commission was conducting a density analysis for the entire Cape. He said the wastewater solutions should and will be different in different areas of the Cape. He disagreed that the Town's public information sessions showed a Town-wide consensus and noted the relatively low turnout (400 people) as compared to the Town's overall population. Mr. Clinton said the Town

needed to investigate the use of STEP septic systems Town-wide. He noted the bulk of the costs from a traditional wastewater treatment plant are in the collection system, and STEP systems are significantly more cost effective. He said the proposed cluster systems are inadequate. He said the adaptive management plan discussed in the staff report is inadequate, in that too much is still unresolved. He noted Mashpee is looking closely at STEP systems and said the CWMP needed to provide a detailed comparison of a STEP system and a traditional sewer system, including information on system design and implementation.

Ms. Vicki Reis said that in 1985, the state designated the Namskaket Marsh system as an ACEC. She said state law relative to ACEC designation requires preservation, restoration or enhancement of the ACEC resources. She said adverse effects to the ACEC must also be minimized. Ms. Reis said Dr. Wieskel's 2005 presentation stated that creek salinity was a function of groundwater discharge to the creek system and mixing with Cape Cod Bay water. She said salt marshes are one of the most productive ecosystems on Earth. Ms. Reis expressed concern that the salinity range in the marsh would negatively degrade the marsh habitats. Ms. Reis said the plume modeling indicates 700,000 gallons of fresh water would enter the ACEC daily, and that this large volume of fresh water would negatively impact the marsh and its salinity. Ms. Reis said these questions were included in the MEPA process through submission to MEPA by Ms. Mary Hartley, and were not addressed. She said the CWMP did not address salinity changes. She said the Secretary of EEOEA was charged to preserve, restore or enhance the ACEC resources, and had not done so. Ms. Reis said the Subcommittee had a duty to deny the proposed project unless it can be shown that there would be no impacts on the ACEC. She suggested the CWMP analysis of the estimated discharge was incorrect, and that the DEP had not addressed Ms. Hartley's questions in the MEPA process. She said the CWMP was not comprehensive.

Mr. Ed Kissell said Ms. Reis had brought up issues of concern to him.

Mr. Nello Trevisan said he had two areas of concern. One was the impact to the ACEC. He also said it was critical to preserve the marsh and that a significant amount of fresh water will discharge to it. Mr. Trevisan also expressed concern about the location and direction of the Tri-Town plant plume, in that he had been told previously that it would flow to Cape Cod Bay. He noted the plume runs under residential areas. He said he had had experience with plumes in his work/career and expressed concerns about the impacts to adjacent septic systems from the plume. He said the proposed project had too high a cost, and did not result in the protection of the marsh and fresh water resources.

Mr. William Grant used a series of figures mounted on foamcore to illustrate his points. He expressed concern about impacts to the marsh from the Tri-Town plant plume and the impacts from the increased fresh water discharge. Mr. Grant said the proposed cost of the plan was staggering, and would not address the impacts. He said the Town should implement cluster systems for hot spots and in the downtown area to protect the marshes.

Ms. Jane Corlette expressed concern about impacts to the freshwater ponds and Cape Cod Bay. She said she did not believe the proposed decentralized systems would work. She said she had experience with a FAST system at her house, and that it did not perform as advertised, taking out much less nitrogen. She said these systems were also hard to monitor and expressed concerns about impacts to the marshes. She noted Dr. Wieskel's comment that the plume was confined by a clay layer.

Mr. Clinton asked if he could respond to Ms. Corlette.

Mr. Putnam said he could.

Mr. Clinton said Ms. Corlette's system was for a single house. He said the systems he had been discussing could collect and treat effluent from up to 1,000 houses.

Mr. K. George Borrnazian said he had been active in the servicing of sewer treatment plants in New York and New Jersey and the costs of the CWMP are unrealistic. He said the plan needed more follow through by scientists and engineers.

Mr. Stuart Peck said the Town should use common sense when trying to figure out complicated issues. He expressed concern about the fresh water transfer from Pleasant Bay to Cape Cod Bay and the marsh.

Mr. Ed Kissell expressed doubt that the clay layer would successfully confine the Tri-Town plant's effluent.

Mr. Paul Ammann, former Chair of the Validation & Design Committee, said he'd read the MEP reports for the various resource areas carefully. He questioned whether the SMAST and MEP models would work. As a result, he questioned whether the CWMP project would result in a betterment of the water quality as desired. He said there is more nitrogen going out of the water bodies than can be accounted for in the models. He noted the Validation Committee had submitted 36 questions as part of technical reports, and these had been submitted to both the DEP and Commission. He said Mr. Dudley had responded, but only answered one of the questions. He noted no TMDL had been developed for Rock Harbor and the boat basin. He requested copies of all the PowerPoint presentations given at the hearing and for an opportunity to submit additional comments.

Ms. Adams said the Commission staff report and PowerPoint presentations, and those given by the Town, including Mr. Giggey and Dr. Wieskel would be made part of the record.

Mr. Putnam asked for final comments.

Ms. Adams said the Subcommittee would need to discuss whether or not the CWMP, as a DRI, was consistent with the tests for a DRI approval and suggested the Subcommittee continue the hearing for procedural purposes to March 15, 2011 at 10:00 AM at the Commission's office in Barnstable, MA so they may find another time to meet.

Mr. Virgilio noted the staff report indicated the project would use road Rights of Ways. He asked that the Town clarify the proposed sewer routes, particularly the overland ones, and whether or not this project aspect would involve potential land takings, and if so, whether this cost included in the CMWP.

Ms. Adams said the staff would seek answers to Mr. Virgilio's question.

Ms. Taylor moved to continue the hearing to March 15, 2011 at 10:00 AM at the Commission office in Barnstable, MA for procedural purposes. Mr. Graham seconded the motion, and it was unanimously approved.

March 15, 2011 Hearing Officer

Ms. Adams acted as a Hearing Officer on March 15, 2011 at the Cape Cod Commission office to

continue a pro-forma hearing on the Orleans CWMP DRI to March 31, 2011 at 10:00 AM at the Commission's office. No presentations, testimony or substantive action was taken on the project at this time. Also present at this Hearing Officer was Ms. Fran McClennen.

March 23, 2011 Subcommittee Meeting

The Commission Subcommittee met to discuss the CWMP and review a March 16, 2011 staff report. The subcommittee voted to hold a subcommittee meeting on Monday, April 11, 2011 beginning at 1:00 PM at the Cape Cod Commission Office in Barnstable. The subcommittee voted to continue the public hearing to Thursday, April 14, 2011 beginning at 6:00 PM at the Assembly of Delegates Chamber in Barnstable.

Mr. Ernest Virgilio moved to accept the minutes of March 1, 2011. Mr. Peter Monger seconded the motion and it came to a unanimous vote.

Mr. Putnam invited Andrea Adams, Senior Regulatory Planner, to provide an overview of the March 16, 2011 staff report.

Ms. Adams noted the additional materials provided in the subcommittee's packet and stated that March 16, 2011 staff report was a bulleted summary of the February 22, 2011 staff report. She stated that the report mentions questions asked by the subcommittee member Virgilio related to the installation of proposed sewer lines and disturbed public and private Rights-of-Way. She said that enclosed with the staff report was a March 15, 2011 response from Mr. Meservey, Orleans' Planning Director, in which he states that the majority of the work will be in the Rights-of-Way of public roads, and if a need arises for the sewers to go across private roads, there is a process for that under State law, and it will be followed.

Ms. Adams noted that the rest of the report is a summary of the 2/22/11 staff report and reviewed it with the subcommittee beginning with Natural Resources.

Mr. Putnam asked the subcommittee if this area needed to be considered any further aside from the outstanding issues or if it was satisfactory to the Commission.

Ms. Taylor asked whether the unresolved issues, such as NHESP's determination, would remain open after the Commission finishes with the DRI review.

Ms. Heather McElroy, Commission staff's Natural Resources Specialist, stated that the NHESP review process would likely not conclude until after the Commission DRI review process so the subcommittee would likely have to condition the project on the Town receiving approval from Natural Heritage. She said that the Town has a consultant working with Natural Heritage and that the project may not result in a take, but if it does the Town will have to address this.

Mr. Putnam asked if the subcommittee/Commission could condition the DRI on whatever mitigation is required for plant and wildlife impacts.

Ms. McElroy answered affirmatively. She stated that she has had a conversation with the Natural Heritage reviewer working on the Orleans CWMP, and she has a great deal of confidence that the Town has been working closely with NHESP to reduce the impacts to Eastern Box Turtles.

Ms. Taylor asked how the bullet points in front of them relate to the 2/22/11 staff report.

Ms. Adams stated that the bullet points in the March 16, 2011 staff report are summaries of the issues raised in the last staff report. She acknowledged that there are a few cases where the 3/16/11 staff report offers clarifications of staff comments, such as with the NHESP, but there is not any new information per se.

Ms. Taylor stated that she still does not see any mention of the fact that Namskaket Marsh is an Area of Critical Environmental Concern (ACEC).

Ms. Adams assured her that it would be acknowledged.

Ms. McElroy also noted that since the 3/16/11 staff report came out, she has had a conversation Mr. Meservey, and he had said that the Town would be willing to abide by a condition in the Commission's decision to provide wetlands restoration, as opposed to replication, as a way of addressing possible impacts from the project to wetland buffers. Ms. McElroy said wetland restoration is consistent with the Commission's standards.

Mr. Virgilio asked about the Rights-of-Way issue, and suggested that private roadways may be in good shape or in bad shape right now. As such, he asked what the condition of the roads would be once the project was completed.

Mr. Meservey stated the roads would be restored to the same condition or better after CWMP related construction had ended, and that he would be willing to put that in writing for the record.

Ms. Adams then proceeded to discuss Open Space issues in the 3/16/11 staff report. She noted that Regional Policy Plan (RPP) Minimum Performance Standard (MPS) OS1.3 exempts municipal projects for municipal purposes from the RPP Open Space provisions and therefore, the Town is not required to provide open space for development associated with the CWMP.

Ms. Adams reviewed the bullet points under the Coastal Resources section of the staff report with the subcommittee point by point, noting that if there are no impacts from construction to coastal resources, many of these points are recommendations to make the project more consistent with the RPP or to protect vital municipal infrastructure from coastal storm flowage.

Mr. Putnam asked if any of these impacts would occur from the proposed project.

Ms. Adams said that she believed many of the references to Coastal Resources MPS were technical assistance-type comments.

Ms. Adams summarized Heritage Preservation/Community Character by stating that Massachusetts Historical Commission (MHC) has determined that significant archaeological resources are unlikely to exist at the Tri-Town site and that a survey should be conducted at cluster system sites, so as to determine if there may be archaeological resources. Ms. Adams said the Town has committed to conducting this survey during the CWMP preliminary design phase. She stated that the project appears consistent with the applicable RPP MPS related to Heritage Preservation/Community Character, and as such, Commission staff suggests the project can be conditioned to allow the necessary surveys to take place.

Under Transportation, Ms. Adams noted that the 2/22/11 staff report indicated that the Town should provide information regarding total daily trip generation for all vehicles for the new wastewater treatment facility, including expected peak hour trips. She said a March 8, 2011

memo from the Town clarifies that the plant is expected to generate less than 25 peak hour trips, and therefore a review of crash records and safety components is unnecessary. She stated that the site distances at the site drive on Overland Way are also adequate based on the information that has been provided, but that a Level of Service analysis for Overland Way has not yet been provided.

Mr. Glenn Cannon, Director of Technical Services for the Commission, stated that the Level of Service analysis would be addressed in the following weeks, but that he does not anticipate a problem.

Ms. Adams noted that thus far, the staff report has covered every issue area aside from Water Resources.

Mr. Cambareri, Water Resources Program Director for the Commission, began on page 2 of the staff report, noting that the CWMP should incorporate the findings of the Nauset Marsh/Town Cove Massachusetts Estuaries Program (MEP)-Technical Report, but because the completion of the study has been significantly delayed, the Town has decided to move forward with a placeholder percent removal of 55%. Mr. Cambareri stated that Commission staff agrees with this decision and recommends that the Town include any revisions in its preliminary project design as a condition of DRI approval when the MEP report is available.

Mr. Richard Roy asked when the MEP Technical Report would be coming out.

Mr. Cambareri responded that it would probably be coming out after the summer.

Mr. Roy asked how 55% was chosen for percent removal.

Mr. Cambareri explained the process for the subcommittee and provided a series of PowerPoint slides to address Ms. Taylor's question relating to the marsh's assimilative capacity. He then showed a slide, which demonstrated the proposed wastewater treatment facility nitrogen budget which replaced the Tri-Town site with the proposed wastewater treatment facility and increased use for that site to 11%, and reduced the excess capacity to 66%. Mr. Cambareri discussed the theoretical build out that resulted in 33% excess capacity suggested by the MEP versus the anticipated build out of 6% resulting in around 60% excess capacity. He noted that the question he was hoping to have answered by the SMAST team related to the split between the Towns of the resulting build out. The final slides that Mr. Cambareri presented showed the mean tide and daily wastewater treatment facility volumes and a contoured plot of modeled salinity in Namskaket Creek system. Mr. Cambareri noted that these slides should answer a number of questions that have been raised, including a letter that came to the Commission from the Town on March 11, 2011. He continued to review the Water Resources section of the staff report with the subcommittee, noting that Massachusetts Department of Environmental Protection (DEP) should clarify the distinction between Little Pleasant Bay and Pleasant Bay, which are treated with separate Total Maximum Daily Loads (TMDLs) and Commission staff continues to urge DEP and MEP technical staff to revisit this issue. He addressed staff report comments on pond impacts and suggested conditions. He stated that Commission Water Resources staff will work with the Town to include specific monitoring of groundwater levels and water quality and stream flow measurements and water quality of the upper marsh system streams in the Adaptive Management Plan and that the Towns of Orleans, Brewster and Eastham should continue their efforts in the evaluation of regional alternatives to allow for cost savings and treatment efficiencies.

Mr. Cambareri reviewed the time line of completion with the subcommittee to demonstrate how adaptive management will take place and stated that the CWMP contains an Adaptive Management Plan to assure TMDL compliance through monitoring and reporting. He said that cluster system design review should also evaluate minor expansion of the collection areas to achieve additional nitrogen removal as part of DRI review. He stated that the CWMP has design review listed in Phase II, but noted that staff suggested moving that component to Phase I.

Mr. Meservey agreed with Mr. Cambareri that the Town would move the design review of cluster systems from Phase II to Phase I.

Mr. Cambareri stated that Commission Water Resources staff would work with Orleans to finalize various aspects of the scope of the Adaptive Management Plan (ADP), prior to moving forward with the preliminary design as a part of the DRI review. He said this includes implementation of the ADP and milestones, documentation of capital expenditures, compliance with the groundwater discharge permit, reporting on Estuary water quality monitoring, summary of habitat assessments that may be completed by the Town, DEP and others, continued coordination with the Pleasant Bay Alliance, and potential evaluations and changes as needed. He noted the items that are proposed for monitoring within the Adaptive Management Plan as listed in the staff report.

Ms. Taylor and Mr. Cambareri discussed how SMAST established a baseline for habitat changes. Ms. Taylor noted the monitoring should include a habitat assessment.

Ms. Adams suggested that the water quality monitoring plan would include nitrogen and salinity, but suggested the other parameters should be discussed with the Town because they would be obligated to do the monitoring. She noted monitoring programs typically establish the baseline, the frequency of monitoring, and the number and type of monitoring wells or sampling points.

Mr. Cambareri added that if the Town sees changes during monitoring, then that might lead to a biological type of assessment of the upper marsh. He suggested there would need to be a threshold or sentinel level of a parameter, so staff will need to discuss this with the Town.

Ms. Taylor asked whether monitoring would include the whole marsh.

Mr. Cambareri stated that it would done through sampling of the upper marsh and mid-marsh sentinel stations to get an idea of the water quality because in the lower marsh, the salinity profile is such that it becomes more difficult to distinguish the marsh from Cape Cod Bay. He then continued his presentation of the staff report, reviewing the progress items to be reported as part of the Adaptive Management Plan.

Ms. Taylor asked about the other ponds that were in trouble and why they were not mentioned in this report.

Mr. Cambareri stated that the other ponds are mentioned in the plan but they are not in this staff report because it deals with areas where there were still issues to be discussed and there are no outstanding issues with those ponds.

Ms. Taylor asked if any of Mr. Cambareri's recommendations regarding the other ponds have changed.

Mr. Cambareri replied that they have not.

The subcommittee discussed the Adaptive Management Plan and Mr. Cambareri stated that the preliminary design plan will take place from 2013-2015 and the conditions that the Commission places on the project will allow for opportunities for discussions with the Town and consultants to fine-tune it. He said once the CWMP moves forward the Commission will be measuring progress and monitoring improvements in the water quality.

Ms. Taylor asked if the project will come back for changes after the MEP model review workshop takes place.

Mr. Cambareri stated that it would come through the Commission as a modification and suggested the Town would also need to file a Notice of Project Change through the MEPA office.

Ms. Adams stated that it could be conditioned in the Commission's decision.

Ms. Taylor stated that Brewster should be part of the process since the Towns share the marsh.

Mr. Cambareri stated that the Towns of Brewster, Eastham and Orleans should continue to discuss the use of the Tri-Town facility as a regional solution and noted the assimilative capacity in the marsh, and stated that Commission staff has tried to shed some light on what the share is for the anticipated nitrogen loads within the watershed and Namskaket marsh.

Ms. Adams stated there will need to be a decision by the Towns about whether they will link into the Tri-Town facility, once upgraded, and as to the resource's assimilative capacity. She noted the marsh does not respect the Town boundary and stated that what she was hearing from Ms. Taylor is that Brewster should not be unduly disadvantaged in terms of having assimilative capacity that it can use if the Town chooses not to pursue regional partnership with Orleans.

Ms. Taylor said that if one Town were dumping sand into another Town it would be very cut and dried, but since it is nitrogen loading, it is more difficult to grapple with. She expressed concern about the Tri-Town facility's impact to the marsh.

Mr. Putnam suggested that perhaps Ms. Wielgus should look into the issue. Mr. Putnam asked what percentage load Brewster is currently contributing to the marsh and said he thought it was 18% of the load.

Mr. Cambareri stated that Brewster is contributing 2/3 or more of the load.

Mr. Putnam asked about the next steps.

Mr. Monger moved to continue the subcommittee meeting to Monday, April 11, 2011 beginning at 1:00 PM at the Cape Cod Commission in Barnstable. Ms. Taylor seconded the motion and it was unanimously approved.

Mr. Virgilio moved to continue the public hearing to Thursday April 14, 2011 beginning at 6:00 PM at the Assembly of Delegates Chamber. Mr. Roy seconded the motion and it came to a unanimous vote.

March 31, 2011 Hearing Officer

Ms. Adams, Cape Cod Commission Senior Regulatory Planner, acted as a Hearing Officer on

March 31, 2011 at 10:00 AM at the Cape Cod Commission office to continue a pro-forma hearing on the DRI to April 14, 2011 beginning at 6:00 PM at the First District Court House, Assembly of Delegates Chamber, Barnstable, MA. No presentations, testimony or substantive action was taken on the project at this time.

April 11, 2011 Subcommittee Meeting was cancelled

April 14, 2011 Subcommittee Hearing

The Subcommittee held a continued public hearing for the purpose of receiving comments on Orleans Comprehensive Wastewater Management Plan (CWMP) as a Development of Regional Impact (DRI). The Subcommittee heard presentations on the CWMP by Commission staff and public comments. The Subcommittee voted to hold a meeting on April 28, 2011 at 3:00 PM at the Commission's office in Barnstable. The Subcommittee voted to continue the hearing to May 24, 2011 at 4:00 PM at the Commission's office in Barnstable.

Ms. Adams provided a PowerPoint presentation on the April 8, 2011 staff report, which is an update to the February and March staff reports. She noted the two prior staff reports had discussed Coastal Resources and Transportation issues. In the area of Coastal Resources, Ms. Adams said construction at the Tri-Town treatment plant site does not impact coastal resources, but some project components, primarily sewer lines, may impact dunes, beaches, and Land Subject to Coastal Storm Flowage (LSCSF). She noted the Town had submitted a 3/31/11 letter in response to comments made in the 2/22/11 and 3/16/11 staff reports. Ms. Adams said the proposed CWMP has a public benefit by mitigating existing water quality impacts to fresh and coastal water quality. Ms. Adams also noted that the Town has clarified that where structures associated with the project are in LSCSF or 100 feet of a coastal resource, and where no feasible alternative exists, the Town will file a Notice of Intent with the Conservation Commission and the Conservation Commission's Order of Conditions will identify the mitigation measures. Ms. Adams said the Town has noted that Section 12.0 of the CWMP includes various mitigation measures designed to address coastal resources impacts. Ms. Adams said Commission staff suggests the Town implement a long-term biological monitoring program for indirect impacts and suggested that such a program could also be a condition of the Adaptive Management Program.

Ms. Adams noted the Town's 3/29/11 response to Transportation issues related to impacts to private and public roads brought up at the 3/23/11 meeting and that the Town will restore roads impacted by sewer line construction. She said a 3/8/11 Memo from Wright-Pierce responds to most of the other issues related to Transportation that were raised in the Staff Reports and reviewed these issues with the subcommittee.

Mr. Tom Cambareri, Commission Hydrologist and Water Resources Program Manager, presented on the Water Resources section of the Regional Policy Plan (RPP). He reviewed the Goals and Minimum Performance Standards (MPS) of the RPP with the subcommittee and discussed how the CWMP meets these goals and standards. He said Commission staff would be looking at the site design relative to MPS WR7.1, MPS WR7.2, MPS WR7.3, MPS WR7.4 and MPS WR7.9, to ensure there was no direct discharge of stormwater, that onsite infiltration was used, and that there was bio-infiltration.

Regarding the issue of assimilative capacity, Mr. Cambareri showed slides of the capacity of the Namskaket system by its existing capacity and excess capacity. He showed a slide which indicated Brewster was using 7% of the system capacity, Orleans 7%, the Tri-Town 19%, leaving 67% excess capacity. He said the numbers were from the MEP report. He showed slides

indicating a proposed nitrogen budget for the marsh with the redeveloped Tri-Town plant which indicated that there would be 63% excess capacity. He showed a slide which included a theoretical build out for the Towns of Brewster and Orleans (as in the MEP Technical Report) and with the proposed sewer plant also on line. He said this indicated there would be 37% remaining excess capacity. He showed a slide of the relative build out, 70% would be from Brewster and 30% from Orleans and a slide of the practical build out from the CWMP, which allows for 26% growth. He said this would leave 56% excess capacity in the Marsh system. He reviewed other measures of assimilative capacity in the water and wastewater management and suggested there is no definitive method to assign assimilative capacity. He suggested the Towns of Brewster and Orleans consider reserving an amount of the marsh's assimilative capacity.

On freshwater flows and dilution, he showed a slide of the mean tidal volume in the marsh and the flow from the treatment facility. He showed a colored slide of the salinity contours and noted the MEP provides yearlong data on the flow at the Creek at Hurley's Bog which shows low salinity (2.4 parts per thousand). He said at 70% the proposed plant's Phase 2 rate would be 0.25 parts per thousand. He said adding the flow at low tide to the Creek would make it about 1.5 million gallons per day and noted that the flow is somewhat diluted. He said the aquifer is over 300 feet thick, which slows moving discharge at the marsh area. He said this is a significant amount of freshwater flow coming in along all the marsh margins and the drainage boundary is something on the order of 400 million gallons per day. Mr. Cambareri noted that the hydrologic assumptions are conservative and Dr. Weiskel's information is even more conservative relative to the location of the plant plume. Mr. Cambareri noted that the MEP technical reports are accepted by the DEP and EPA as determining the nitrogen critical loads and have become established TMDLs which are adopted by Barnstable County in the RPP.

Mr. Cambareri addressed a point made in a 4/7/11 letter about a choice of quotes in Mr. Cambareri's report at the 3/1/11 hearing. He said the Woods Hole Summary Report notes the level of skepticism involved with complying with the TMDLs. Mr. Cambareri said the Report notes there may be a tendency to avoid public expenditures and for stakeholders to develop conclusions that are inconsistent or at odds. He said the Report acknowledged that it would potentially increase confidence in the MEP report and identify potential sources of uncertainty. He said that Commission staff is confident in the MEP science and that the proposed CWMP will result in a reduction in nitrogen, and an improvement in water quality. He noted the primary use of Septic Systems to treat wastewater on the Cape has resulted in declines in water quality.

Mr. Cambareri then addressed the breach that that occurred in Pleasant Bay in 2007 and he noted the phases of the CWMP would allow for the incorporation of new information and technology which is particularly important with respect to the upper headwaters and the impaired ponds. He noted Section 11 of the CWMP dealt with the scope of the preliminary design and it allows the Town to confirm and update decisions reached during the planning process based on several factors and confirmatory modeling. Mr. Cambareri said the modeling would then feed into sewer phasing and the Tri-Town site disposal limitations. He noted it could also be adjusted for negotiations between Orleans, Brewster and Eastham on regional solutions and stressed the importance of regionalization. He said the Adaptive Management Plan would also be updated based on annual monitoring reports which would include re-assessing the CWMP with respect to Cedar Pond. He touched on the non-structural methods to address nitrogen removal and noted Commission staff suggested the Town of Orleans move the design of cluster systems up in the project schedule, so that implementation of some components can occur in Phase I and also suggested the Town evaluate expansion of cluster

systems to achieve additional nitrogen removal. He noted the components of an Adaptive Management Plan that would be part of the DRI decision on the Town's CWMP.

Mr. Putnam asked for comments from Federal, State, Regional and local officials.

Ms. Fulcher, Chair, Orleans Board of Selectmen, submitted a copy of a letter for the record, and read her remarks into the record. She said the Board of Selectmen believes wastewater issues on Cape Cod must be addressed to protect natural resources for the enjoyment of current and future residents. Ms. Fulcher said the Town trusts the responses to the Commission's questions have been satisfactory, and that the Town will continue to answer any questions. She also commented on environmental protection and regionalization issues and noted the CWMP has undergone MEPA review prior to commencement of Commission review and that it would also require a Groundwater Discharge Permit and a formal site assignment from the MADEP. She said the CMWP had been carefully engineered to allow the Town to move ahead on its initial phases while having the flexibility to incorporate new information and technology into later phases. She said that Orleans, Brewster and Eastham have a history of working together to solve wastewater problems and noted the Tri-Town Groundwater Protection District had been in effect since 1985 and the Towns had worked together to build a single treatment facility. She said the Orleans CWMP provides an opportunity for the Towns to continue working together and noted a Regionalization Study funded by the Water Protection Collaborative demonstrated that the Towns could save money by pooling resources on a sewer facility. She said the three Boards of Selectmen had met together on several occasions to discuss their needs and interests and these discussions had been informal and cordial. She said they understood the issues did not respect political boundaries and that questions regarding Namskaket Creek should be resolved between the Brewster and Orleans Selectmen. Ms. Fulcher said the CWMP as presented is consistent with the Regional Policy Plan and merits approval.

Mr. Putnam asked for questions from the Subcommittee.

Mr. Monger asked if any thought had been given to managing pharmaceuticals in wastewater.

Ms. Adams noted that based on her history of working with hazardous wastes, she was very aware of the issues surrounding management of pharmaceuticals. She said the County and Cape Towns have been aggressive in seeking services to deal with household hazardous waste and the best and easiest way to manage pharmaceuticals is to return them to doctor's offices. She said the issue would need to be resolved at the federal level to address the problem nation-wide.

Mr. Cambareri said the proposed wastewater treatment plant (WWTP) would provide a high level of nitrogen treatment and it could provide an opportunity to remove pharmaceuticals from wastewater. He said there are current state regulations dealing with this for WWTPs located in Wellhead Protection Areas/Zone IIs but there is no outright prohibition. Mr. Cambareri said keeping residential density low also helps address the issue of pharmaceuticals from humans in wastewater. He said there are non-profits and other groups working to better characterize the problem. He said there are very few, if any, detections of compounds in wells not in village centers as opposed to those surrounded by development.

Ms. Taylor asked if the WWTF design would be flexible enough to incorporate future methods to address pharmaceuticals in wastewater.

Mr. Cambareri said the way to help address this is through the Adaptive Management Plan, and its monitoring/compliance program. He noted the Groundwater Discharge Permit (GWDP), which is renewed every five years, would likely incorporate ways to deal with pharmaceuticals in wastewater.

Mr. Putnam asked for public comments.

Vicki Reis submitted written comments on behalf of Mr. Paul Amman and read a copy of his letter into the record. Reading Mr. Amman's letter, she said on March 11, 2011, Mr. Meservey, on behalf of the Town of Orleans addressed several issues that were raised at the March 1, 2011 public hearing on the Orleans CWMP. Mr. Amman's letter commented on a number of these issues. First, reclassifying Rock Harbor under the MEP he said, is wrong because it has never been peer reviewed and is not available to the public. He said the water quality measured by MEP in Rock Harbor is equal to or better than that in both Namskaket and Little Namskaket Creek at similar locations. Neither of these two systems has been classified by the MEP as impaired and the MEP reason for declaring Rock Harbor as impaired is because of unhealthy benthic community in the Rock Harbor boat basin. He said that MEP associates this observation with nitrogen in the water column, and ignores the main cause, which he says is that salt marsh organic matter is transported from the Rock Harbor salt marsh into the periodically dredged boat basin during ebb tides. He says this is the source of the problem, not nitrogen in the water column. He also said the Rock Harbor boat basin has been determined by DEP to be an open embayment, not part of the larger marsh system, because it has been dredged. But the Rock Harbor boat basin, he said, is strongly influenced by the tidal exchange with the marsh system and the current classification of the Rock Harbor boat basin is open to challenge. He said simple calculations show that nitrogen concentrations in the boat basin cannot be reduced to the MEP specification even if all septic nitrogen is removed. He also noted that a TMDL report has not been issued and probably will not be available until 2015 or later and the TMDL document for Rock Harbor will not be released until after the MEP study on Cedar Pond is completed. The letter went on to discuss Namskaket salinity change and showed table values on the salinity, discussed Mr. Meservey's statement regarding freshwater in the salt marsh and the Wright-Pierce evaluation of the potential freshwater inputs to Namskaket Creek, and addressed the impacts to Namskaket Marsh and the ACEC.

Ms. Reis then made comments of her own behalf. She said she also had a packet of information to submit to the Subcommittee. She said the concept of adaptive management was not sufficient to solve the problem and used the Tri-Town plant as an example, saying it has failed in that the plant was over-built, and has had operational, financial and management problems. Ms. Reis said Namskaket Marsh was designated an Area of Critical Environmental Concern (ACEC) in 1985 and it includes hundreds of acres of salt marsh, shellfish beds, salt ponds and critical habitat. Ms. Reis noted the ACEC provides important storm surge protection and recreational opportunities. Ms. Reis noted the closures of shellfish beds dating back to 1988 and no one from the Towns of Brewster or Orleans have contacted the state to determine why the beds have been closed. She said the Namskaket and Little Namskaket Marsh have been declared impaired waters and tidally-restricted salt marshes on the Commission's website. She restoration projects have been done by the DEP and her packet of information included an ENF for one of them. Ms. Reis said the Subcommittee has heard that the Town voted on the CWMP. She said the Town voted in October 2008 on a draft plan and a newspaper article makes note that it was a draft, and that the final plan would also be the subject of a future vote, which has not happened. She said there was not overwhelming Town support for the CWMP and that only 100 people turned in surveys. She noted the Town was losing population, and the build-out analysis in the CWMP was flawed. She said the CWMP includes a lot of ambiguous language

and Dr. Wieskel does not know where the plant plume is or where it is going. She said she appreciated that the Subcommittee was taking its time in reviewing the CWMP and stated that the Town residents were concerned about impacts to the natural resources, and the fiscal impacts to the residents.

Jeffrey Eagles read a copy of his written comments into the record. He said he was a professional engineer and environmental scientist by training. He discussed the impact that the proposed Orleans wastewater treatment plant would have on salinity levels and the plant and animal habitat in the Namskaket and Little Namskaket tidal salt marshes. He said he had read the March 2011 letters from the Town of Orleans and Wright-Pierce and differed with their conclusions. He said the Commission should keep in mind the DEPs two objectives in pursuing nitrogen reduction, which were water quality improvement and healthy plant/animal habitats. He noted that averages are not instructive and both the Town and Wright-Pierce use averages to compare the sewage treatment plant's freshwater discharges, incorrectly comparing them to the groundwater flow rate and to the Marsh's tidal prism. Averaging the impact over the whole marsh, the percentage increase of freshwater is small. However, Mr. Eagles said this is in conflict with how the discharge will actually enter and move through the marsh as it will not be uniformly spread over the marsh. He noted Dr. Weiskel's presentation highlighted this, noting Dr. Weiskel's points that the impacts would be localized to the marsh's margins and in creek beds. Mr. Eagles said the increase in freshwater flows in localized areas in the marsh will negatively impact plant and animal habitat through salinity changes and will degrade habitats. He said Namskaket and Little Namskaket Marsh are two sensitive natural open space areas and part of an ACEC, which the Commission staff reports and Town letter fail to acknowledge. Mr. Eagles said Massachusetts's law protects ACEC and requires us to protect them as well. He said the Orleans Conservation Commission and the Orleans Conservation Trust also have a duty to protect the ACEC. Mr. Eagles noted a joint meeting on 2/12/09 to discuss a list of engineering solutions for improving water quality in Pleasant Bay and that one of the suggested solutions was to pump oxygen-rich seawater into Meetinghouse Pond. He said the Orleans Conservation Trust declared this was not allowed because it would alter the salinity of the Pond, which is part of the Pleasant Bay ACEC. He questioned why the Town would reject an engineering solution which would alter the salinity of part of the ACEC but will not acknowledge the proposed CWMP will do the same thing relative to the Marsh, which is also part of an ACEC. He questioned why the Pleasant Bay ACEC would be improved in a manner that would damage the Marsh ACEC. He urged the Commission to protect the plant and animal habitat in the Marsh ACEC.

Carolyn Kennedy said she had served as the Chair of the Marine and Freshwater Quality Task Force which is tasked with conducting sampling in Orleans, and also assisted in sampling in the Namskaket Creek to determine the impact of the Tri-Town plant. Ms. Kennedy said that since June 2010, the group, under the direction of Dr. Wieskel, United States Geological Survey (USGS), has sampled in 3 locations, alternating with a USGS employee, so that the Creek is sampled twice a month. She said the results of these samples and tests show no trends versus the prior round of samples in 2003-2004. Ms. Kennedy said a new sewage treatment plant would provide a higher level of nitrogen treatment, resulting in a no-net increase in groundwater. Ms. Kennedy noted the Task Force members have been in the Marsh over the seasons, including the winter, and that the Marsh is vibrant based on noted animal tracks and other animal observations. She noted there have been concerns raised as to why the shellfish beds at the mouth of Namskaket Creek have been closed. Ms. Kennedy said in the 1980s, the Orleans Shellfish Officer selected the most productive beds to undergo surveys. She said the ones at the mouth of the Creek were not selected to undergo the required survey because they were not the most productive areas in Town. She said the state determined that high fecal

coliform levels from animals in the Marsh precluded the Creek beds from being opened to human harvesting. She said the animals in the Marsh act as a reservoir for these bacteria. Ms. Kennedy said these determinations occurred prior to the Tri-Town plant being brought on line in 1989-1990.

Jane Corlette acknowledged the Commission's review of the CWMP and the CWMP's flexibility. She said the important issue is the deterioration in fresh and salt-water quality. She said she's seen the deterioration over her own lifetime. Ms. Corlette said the impacts are from septic systems and to a lesser extent, lawn fertilizers and stormwater runoff. She said the DEP will also review the project and will not grant a GWDP unless the Marsh will remain healthy. She supports continued monitoring of the Marsh and noted sewering is a tested technology to address the main issue, nitrogen, and possible pharmaceuticals affecting the Marsh.

Chet Crabtree said he was a member of Orleans Planning Board but was speaking as a private concerned citizen. He said the plan under consideration is unique in that it will be implemented over two to three decades. He said this multi-year, multi-phased approach offers sufficient flexibility to make corrections as improved technologies are available. He said the Town has closely examined both a centralized and decentralized system, and after extensive review, the Town has chosen a centralized system, which will serve 52% of the Town's homes. He said this approach was approved at a 2008 Special Town meeting and the Town later modified the plant to include up to five decentralized cluster systems in remote locations near waterways and wetlands. He said these cluster systems will be installed as part of an earlier phase, in order to more quickly address the quality of ponds and bays. He said the plan can also determine if the cluster systems should remain or be connected to the larger sewer system. He said the Orleans Planning Board, cognizant of the DRI approval process, reviewed the CWMP for its consistency with the Commission Act, Regional Policy Plan, Orleans bylaws and Orleans Comprehensive Plan and concluded that the CWMP is consistent with all four of these.

Len Short said he was in support of the CWMP, and suggested that the Subcommittee and full Commission endorse it as well. He said his support was based on protecting all of Orleans's waters, ponds, marshes, and estuaries. He said these represent the aesthetic and economic heart of Orleans. He said the CWMP is adaptive to new technologies and approved by the County. He said it is critical that all Orleans' waters, including the Namskaket Marsh system, stay below the TMDLs to maintain a healthy ecosystem. He said questions have been raised and responded to and urged the Commission to move the Orleans CWMP forward.

Judith Bruce said she was speaking for herself, although she had been a member of the Orleans Wastewater Management Steering Committee for six years. She said she had been to all the hearings, and understood the concerns related to the Marsh and impacts on abutting properties from plant effluent. She compared the current debate to that which had taken place related to the Boston Harbor sewage outfall pipe. She said she had been opposed to this project. However, she said that ten years of monitoring of the outfall pipe indicates no negative impacts have resulted. She said monitoring of the Tri-Town plant to date shows no negative impact to the Namskaket area. Ms. Bruce said the proposed and current monitoring should continue, including sampling to determine where the effluent plume is flowing. She urged the Commission and DEP to make project approval contingent on a strong monitoring component for the life of the plant. She said the CWMPs Adaptive Management plan would respond to changing conditions and technology and suggested the Town consider using treated effluent in public buildings for toilet flushing and to irrigate ball field and golf courses as a way to conserve plant capacity. Ms. Bruce said use of the decentralized cluster systems was a good idea. She said the Town of Brewster has been involved in discussions to date, and urged the Boards of

Selectmen to work together to resolve common issues. Ms. Bruce said the health of the ACEC would continue to deteriorate, and said the CWMP and sewering was part of addressing this problem. She urged the Commission to approve the CWMP.

Nello Trevisan said Adaptive Management in this form is trial and error. He questioned what would happen if the proposed plan did not work. He said the Marsh already has a balance of salt and fresh water and was concerned that the proposed 600,000 gallons per day of plant effluent would disrupt this balance. Mr. Trevisan said he thought Mr. Cambareri said that the discharge *"might be somewhat polluted"* but that this was not a problem.

Mr. Cambareri said he was not certain of the context of what Mr. Trevisan was talking about.

Mr. Trevisan said that fresh water is a pollutant at low tide and he thought it was illegal to pollute anything in an ACEC. He acknowledged the nitrogen loading level will be low enough that it will not hurt the Marsh but said the fresh water effluent from the plant will hurt the Marsh. Mr. Trevisan said averages do not work in this situation, with respect to the fresh water impacts to the Marsh. He said he had understood that the plant plume would carry the fresh water under the Marsh to Cape Cod Bay, where it would be diluted, which he now understood would not be the case. He said the Commission's Executive Director was quoted in the newspaper as saying that he was concerned about the $4-$8 billion dollars of wastewater expenditure on the Cape, and that that amount of money would cause such a drain on middle and low-income residents and homeowners that they would leave the Cape, significantly changing the Cape's demographics. He said the CWMP has a proposal for how this would be paid for, and the owner of a $300,000 home would have their taxes increased by 125%, which is over double. He said the tax increases on higher valued homes is significantly less, between 65% more for a $600,000 home, and 40% increase on a $1.5 million dollar home. He acknowledged 40% of $1.5 million was a large number, but the burden is on the low and middle-income homeowners. He recommended these issues needed to be addressed before the CWMP moved forward.

Steve Ellis said he had heard Spade foot toads calling outside, behind the Tri-Town plant site. He said they were an endangered species.

Mr. Ellis said that as a fisherman whose family has lived in the area for over 350 years, he is very concerned about the impacts to the Marsh. He said Orleans' Town activities, from the Department of Public Works and the Harbor Master are impacting the Marsh. He noted the state highway drains into the Marsh and he noted the work that had been done to open up culverts to increase tidal flushing. He said it is obvious to him that Orleans Town officials do not care about the Marsh. He said his family was leaving the Cape next year due to the increasing tax burden. Mr. Ellis said the treatment plant effluent would negatively impact the shellfish beds and eelgrass. He said the shellfish beds at the mouth of Skaket Creek are the largest beds in Brewster and in the Town of Orleans on the Bay side. He said these were closed in 1987 because of *E. coli*. He said Mr. Mayo in Provincetown said these beds are closed now because of chemicals. Mr. Ellis said the endangered species study and the ecological report for the project are questionable. He quoted a portion of the report that states that the site should be recommended for an eligibility determination to the National Register of Historic Places. Mr. Ellis also said that there has never been a herring fishery in the creek, but they do go up the creek to the ponds. Mr. Ellis concluded that there were too many questions, and he thinks people were getting paid off. He submitted four color photographs for the record.

Eric Schwab said he lived in Hyannis. He said he was involved with Barnstable's sewer plan and the Orleans' CWMP is a cookie-cutter copy of Barnstable's plan. He said it would result in higher density housing. He said the Town of Orleans was making a really bad mistake.

Mr. Putnam asked for any other comments or questions from the subcommittee.

The subcommittee agreed to save questions for the subcommittee meeting.

Ms. Taylor moved to hold a Subcommittee meeting on April 28, 2011 at 3:00 PM at the Commission offices. Mr. Roy seconded the motion, and it came to a unanimous vote.

Ms. Taylor moved to continue the hearing to May 24, 2011 at 4:00 PM at the Commission office in Barnstable, MA. Mr. Roy seconded the motion, and it was unanimously approved. The Subcommittee adjourned.

April 14, 2011 Subcommittee Meeting

The Subcommittee meeting scheduled for after the public hearing on April 14, 2011 was not held.

April 28, 2011 Subcommittee Meeting

The Subcommittee met to discuss the Orleans CWMP and review the staff report. The meeting was continued to Tuesday, May 24, 2011 to begin immediately following the continued public hearing to be held at on May 24, 2011 at 4:00 PM at the Cape Cod Commission Office in Barnstable.

Mr. Putnam invited Andrea Adams, Senior Regulatory Planner for the Commission, to provide updates for the project.

Ms. Adams noted the additional materials provided in the Subcommittee's packet and stated that the Subcommittee has already seen the majority of the material because it was submitted at the April 14, 2011 public hearing. She distributed copies of an Email received from Susan Broderick, the Administrative Assistant to the Brewster Town Administrator with a letter attached from the Town Administrator, Charles Sumner, addressed to Paul Niedzwiecki, Executive Director of the Commission. Ms. Adams read the letter aloud into the record, which expressed concerns about the lack of participation by the Town of Brewster in the decision making process for the project. Ms. Adams noted that as project manager, she has not yet been directed to begin drafting a decision. She stated that she had received a similar request from Susan Leven, the Town Planner for the Town of Brewster, who asked for a copy of the draft decision, and stated that she emailed Ms. Leven back and stated that perhaps she was looking for a Staff Report. Ms. Adams reviewed the meetings and hearings that have taken place to date. Based on Mr. Sumner's letter, she said, it appears that people still have some concerns with the marsh, but said that she feels that at the March 23, 2011 meeting the Subcommittee was able hear the issues and the Commission staff reports and PowerPoint presentations covered many of them. She stated that perhaps the Subcommittee could limit today's discussion to issues that only concern the Town of Orleans and leave some of the other issues until a later date so that more information can be provided to the Subcommittee on issues affecting the marsh and the Town of Brewster.

Mr. Putnam asked if the Town of Brewster or Mr. Sumner has filed information with the Commission previously.

Ms. Adams stated that there have been letters that have come in from the Town that have been submitted to the Subcommittee, as well as comments made by Elizabeth Taylor as the Brewster representative.

Mr. Putnam expressed concern for the lack of positive cooperation between the Town of Orleans and the Town of Brewster and stated that the marsh has been talked about as if it was a single entity and it should be discussed as though it is a part of Brewster as well. He stated that cooperation between the two Towns is very important and that Brewster should express their concerns to the Commission.

Ms. Adams noted that the staff reports have accounted for the assimilative capacity of the marsh, at least in terms of nitrogen, and have accounted for the programmed build-out in those terms. She stated that Commission staff has been aware that the resources do not respect that political boundary. She suggested that staff could meet with the Town about their concerns. Commission Water Resources staff comments deal with regionalization and recommend a regional solution.

Mr. Putnam suggested that Brewster be involved in the planning for this project.

Ms. Adams noted that George Meservey, Director of Planning and Community Development for the Town of Orleans, was present and could perhaps speak to the issue, but she stated that one part of the components of an Adaptive Management Plan is to have a milestone where Orleans has another look to determine whether Brewster may come into the proposed wastewater treatment facility given Brewster's level of wastewater planning.

The subcommittee discussed including Brewster in the planning of the project.

Mr. Roy asked about the deadline for this project.

Mr. Putnam said that there is a deadline for the Commission to make a decision on the project, but that it could be extended.

Ms. Taylor stated that the Town of Brewster wants to be at the table and be involved in the decision making process. She stated that she has not seen any recognition in the reports of what percentage of the marsh belongs to Brewster and they should be involved in this. Ms. Taylor said that this has been expressed before but not as pointedly.

Mr. Putnam agreed.

Ms. Adams noted that Mr. Sumner's letter specifically seeks a meeting and stated that she would be willing to arrange such a meeting.

Ms. Adams suggested that the Subcommittee discuss some of those issues that do not relate to Brewster and then have Commission staff get some more information from the Town and set up that meeting to discuss any outstanding issues.

Mr. Tom Cambareri, the Water Resources Program Manager for the Commission, stated that staff was aware of the concerns from Brewster, including from Ms. Pat Hughes from the Water Quality Committee, who testified at a hearing in Orleans and asked about monitoring and assimilative capacity. He also noted the 2/28/11 letter from Brewster Board of Selectmen Chair Ed Louis to the Orleans Board of Selectmen. Mr. Cambareri said Mr. Louis suggested that if the

cluster systems were made permanent there would be less water going to the Tri-Town facility. Mr. Cambareri stated that monitoring would be a condition of any DRI decision. In response to the concerns about assimilative capacity, he stated that the Commission engaged SMAST to do an assimilative allocation from their model and that was presented at the March 23, 2011 Subcommittee meeting, and again at the April 14, 2011 public hearing. Mr. Cambareri noted this information was not contained in the April 8, 2011 staff report, so perhaps Brewster does not have all the information that the Subcommittee has. In relation to the cluster systems, Mr. Cambareri stated that the staff's recommendation was to expedite the cluster systems within the CWMP plan of implementation, and that was something the Town of Orleans had agreed with. He said that the Commission could sit down with the Town of Brewster and address any other concerns they may have.

Mr. Virgilio stated that he feels that most questions at this point in time have been repeated and answered more than once, so in order to have a meeting, the Town of Brewster should be specific and ask questions that are different than those that have already been answered because he does not want to review the same information again. He said that a lot of work has been done on this project and he does not want to spend time going over the same information.

Mr. Putnam stated that the essential construct of the Commission is based on regionalization, which means that all of the parties involved in a particular issue should be included. He said that Brewster has all the information and what is not clear to him is precisely what they want to hook the decision on, so he would like to see from Brewster exactly what they would like to discuss and would like to see the two Towns meet on this.

Ms. Taylor said that the Town of Brewster is looking for acknowledgement that the marsh is mostly in Brewster and that the Town of Orleans is proposing to use it. She stated that it does not have to be done before the Commission process is over, but it should be stipulated in the decision that there will have to be some sort of agreement between the towns. She said that developing a CWMP is a long process and nothing is proposed to go into the marsh for a few years so there is plenty of time for discussion.

Ms. Taylor asked Mr. Cambareri if multiplying the amount of effluent in the marsh would change the direction of the water.

Mr. Cambareri said that it is a complicated answer, but the plume does have a direction, and some of it discharges to the creek and some of it travels under the marsh and eventually to Cape Cod Bay. He said mounding is a factor, and when you increase the discharge to groundwater, the mound will get bigger and the flow from the Tri-Town facility would widen. He said it depends on the hydraulic boundary condition, and the creek is the low point in the system from the Orleans side. Based on this, he suggested the mound of the plume would not be expected to travel into Brewster on that side. On the other side, he said, the increased flow would discharge into Little Namskaket creek.

Ms. Taylor suggested that the reports clarify that the shellfish beds were in trouble way before the Tri-Town septage plant was built and/or operational, and that it is not a nitrogen issue, it is a bacteria issue that is caused by sea birds, and other animals living in and around the marsh.

Ms. Adams stated that information from the US Division of Marine Fisheries about the shellfish beds was presented at a previous hearing and was provided to the Subcommittee.

Mr. Roy stated that it was also provided in testimony from another gentleman at a hearing.

Mr. Putnam said that the creek had been altered about 75 years ago during the mosquito control phase and straightened out to a degree and asked Mr. Cambareri whether that affects the subsurface flow of material going in.

Mr. Cambareri stated that he does not think so.

Mr. Putnam asked Ms. Adams how she would propose the two Boards of Selectmen meet.

Ms. Adams stated that for other projects, Commission staff met with the Board of Selectmen or Town Planners and provided a presentation of those issues addressed by staff reports.

Mr. Virgilio asked if there was ever a meeting between the Towns of Brewster and Orleans.

Mr. Meservey stated that Orleans, Brewster and Eastham have met at least three times to discuss the Tri-Town facility since the three Towns have an interest in it and to deal with the nitrogen loading issues. He said that the draft of Orleans' CWMP has been around since April of 2008 and it was sent to the two Towns. He said he understands that as more details are provided the towns learn what their concerns are, but primarily, to date the discussions have been about the Tri-Town facility and how the agreement that is in place now to run the plant might need to be changed to allow a sewer plant to go in. He said that a meeting with Brewster is something that could be done outside of the DRI process and the Orleans Selectmen would be open to that.

Mr. David Dunford, Selectmen for the Town of Orleans, affirmed that the Board would be willing to meeting with the Town of Brewster, and he stated that what they are really talking about is the fate of the Tri-Town facility.

Mr. Putnam stated that the input level from the Tri-Town site would be altered dramatically and Brewster owns 75-80% of it.

Ms. Adams noted that the Brewster and Eastham Town Clerks have been sent Commission hearing notices.

Mr. Putnam suggested that Ms. Adams be requested by the Subcommittee to meet with the planners for both the Town of Orleans and Brewster to determine the best way of getting the two Boards of Selectmen to sit down and discuss what they perceive as the issues and come back to the Subcommittee with a list of the issues that exist between the two Towns. Mr. Putnam stated that the Subcommittee is concerned because the facility is being used to augment what is coming out of Orleans, and they are concerned with what can happen to Namskaket marsh as a result of the effluent being pushed into it from the Tri-Town facility and there should be agreement from Brewster that this is acceptable.

Mr. Cambareri stated that the 4/28/11 letter from Mr. Sumner was addressed to the Executive Director and the last statement was that the Town of Brewster would like to meet with the Town of Orleans, the Commission, and DEP to resolve these issues before the Commission renders a decision, and perhaps this should be addressed by the Commission's Executive Director.

Ms. Adams said staff can provide the Subcommittee with feedback on what came out of the meeting with the Town of Orleans and Brewster officials.

Mr. Putnam stated that he does not see how the DEP is going to add anything to the discussion between the two Boards of Selectmen. He said that the DEP will determine whether what is done to Namskaket marsh is acceptable from an environmental basis, but they would not resolve the requirement of the two towns to agree as to the common issues.

Ms. Taylor said that the Department of Natural Resources for the Town of Brewster has been involved in this, so perhaps Chris Miller should be invited to participate in the discussion, whether as an adjunct to the Selectmen who are not natural resources specialists. She stated that there is a lot to think about plenty of time to have these discussions without holding up the process.

Ms. Adams stated that Commission staff could reach out to the Boards of Selectmen and the Town Administrator who wrote the letter and ask them who, from Brewster, should be involved in the meeting.

Mr. Putnam stated that both Brewster and Orleans representatives should be at the meeting.

Mr. Roy suggested the meeting take place sooner rather than later because if it is decided that nothing can go into the marsh, it needs to be known before any decisions are made.

Ms. Taylor suggested that it could be conditioned in the decision that these conversations must take place.

Mr. Putnam stated that they should address Brewster's concerns before they discuss anything further.

The Subcommittee voted to continue the Subcommittee meeting to May 24, 2011 following the public hearing to be held at 4:00 PM on May 24, 2011 at the Cape Cod Commission office.

Mr. Roy asked about a previous statement made by Mr. Cambareri relating to one of the points in the letter received by the Commission. He asked whether it stated that the cluster systems should be permanent.

Mr. Cambareri said that the letter suggested that the cluster systems would reduce the flow at the Tri-Town facility.

Mr. Roy asked if the cluster systems do not reduce the nitrogen load to Pleasant Bay, whether they can be considered permanent.

Mr. Cambareri stated that it would be part of the Adaptive Management Plan, that they would evaluate the cost effectiveness of the cluster systems. Therefore, he said, he does not believe the Town of Orleans would agree to make them permanent at this point.

Ms. Taylor asked if the National Academy of Science reviews the process and it somehow affects the project, whether the Staff Report would be modified or whether it would fit into the adaptive management plan.

Mr. Cambareri suggested that could be stipulated for in the decision.

Ms. Adams said that the Adaptive Management Plan could include information from any number of sources and that could be put into the decision as well. Credible sources should be used to help address any problems that might occur.

Staff and the subcommittee discussed the process for incorporating an adaptive management plan into a DRI.

May 24, 2011 Subcommittee Hearing

Mr. Roger Putnam opened the hearing at 4:00 PM and invited Andrea Adams, Senior Regulatory Planner for the Commission, to provide updates for the project.

Ms. Adams noted that the subcommittee has been given a packet of information for their review which consists of everything that has come in since their last public meeting on March 28, 2011 as well as a draft set of minutes from the April 14th public hearing and the April 28th subcommittee meeting. The meeting took place between the Town of Orleans and the Town of Brewster on May 12, 2011, as directed by the subcommittee at the last meeting, and was attended by Commission staff, members of the Board of Selectmen for the Towns, and Brian Dudley of the DEP. Based on that meeting, the Town of Orleans drafted a written proposal which Ms. Adams read into the record and gave to the subcommittee for review. The proposal included several conditions of approval for the Commission to consider and served to ensure cooperation between the Towns with regard plan. She also noted that the subcommittee had in their packets, a letter dated May 18, 2011 from Peter Norton, the Chair of the Brewster Board of Selectmen to Mr. Niedzwiecki, thanking him for arranging the meeting with the Town of Orleans and making a request to move forward with the process. Ms. Adams also read this letter into the record and noted that she had received a correction to the letter from Susan Levin, the Town Planner for Brewster, which made note of the incorrect use of the phrase TRC. Ms. Adams stated that Commission staff is available to provide additional feedback on the discussions that took place at the meeting. She noted that the subcommittee came to a consensus opinion at the March 23rd meeting and the April 14th hearing that the Regional Policy Plan issue areas of Open Space, Heritage Preservation, Transportation and Coastal Resources either did not apply to the proposed project or that the impacts from the construction of the sewer lines, pump stations, and cluster systems could be addressed through conditions.

Mr. George Meservey provided an update on behalf of the Town of Orleans. He stated that the Town has received letters from three residents, which were also sent to the subcommittee, stating that there is insufficient data serving as a basis for the CWMP, and that an upcoming study will fundamentally change the wastewater plan. Mr. Meservey responded to these contentions, citing the CWMP. Mr. Meservey noted for Pleasant Bay, the final MEP technical report was issued in May, 2006. For the waters on the Cape Cod Bay side, Namskaket Creek, Little Namskaket, and Rock Harbor, the final MEP report for each of those was issued in December, 2008. For the Nauset system, which is the fifth system in Orleans, the Town relied on an assessment by the MEP technical team. Mr. Meservey proceeded to summarize the letter that was distributed to the subcommittee and submitted for the record. He stated that the final MEP reports for Namskaket and Little Namskaket indicate that the assimilative capacity is greater than the present day or future loads and therefore there are no TMDLs anticipated for either of those creeks. For Rock Harbor, he said, the DEP is in the process of a reevaluation of Cedar Pond, which is a headwater, freshwater, or saltwater pond, and the study may indicate that the pond is nitrogen limited whereas previous reports stated that it was a freshwater pond and phosphorus friendly. If the change is true, he noted, it would increase the need for septic nitrogen control. He stated that in the plan, when all six phases are done, virtually the whole watershed leading into Cedar Pond will be sewered. Mr. Meservey said that Pleasant Bay is the

biggest system to deal with, as is demonstrated in the MEP. The TMDL has been issued for this system, he said, and it's been established that there is a threshold nitrogen concentration that is independent of the current breach. The DEP has advised the Town through numerous discussions that the MEP report is a valid technical basis for the wastewater planning on that system. Concerning the new inlet itself, Mr. Meservey stated that the Town knows of no technical analysis that indicates that the breach will remain in place for 50-100 years, but if there is an expert that has found that analysis, he said the Town would be happy to look at it. He said that the Town relied on an assessment by the MEP technical team that set a 55% nitrogen load reduction target for that area. The Town had their consultant conduct a sensitivity analysis that showed that the cost of the CWMP would vary about 10% if the nitrogen reduction were 40%-70% on the high and low end with the adaptive management plan and the many phases of it, he said the Town believes there is ample time to make necessary corrections or adjust to the report when it comes out. Mr. Meservey stated that there was an article approved at the annual town meeting that would fund an evaluation of the STEP (Septic Tank Effluent Pump) collection system as an option to save money on the plan. The proposed plan currently has a hybrid system that is a combination of traditional gravity and alternative collection systems where appropriate. He assured the subcommittee that whatever means are selected to collect wastewater will not fundamentally change the plans.

Mr. Cambareri stated that many of the concerns that have been identified have been addressed through the adaptive management plan and through suggested conditions provided by staff.

Mr. Putnam then invited members of the public to speak.

Mr. Ed Daly spoke first as a resident of Orleans. He read a letter that he wrote which he submitted for the record which summarized his reasons for feeling that the DRI cannot now be properly assessed based on the system described in the current draft CWMP. He used Pleasant Bay as an example, stating that the TMDL was based on water quality, eelgrass and benthic community data collected for the years between 2000 and 2005, but that it now meets the DEP nitrogen specifications at their principal sentinel station and an April 2007 breach has been driving nitrogen levels even lower and stated that coastal scientists say the breach will remain open for 50-100 years. He went on to discuss the other areas addressed by the CWMP and stated his reasons for believing that the CWMP is based on guesses and assumptions without any public comment or scientific review by the residents of Orleans. He stated that there are no final MEP reports or TMDLs for 50% of the watersheds and an obsolete TMDL and incorrect system concept for the other 50% and that they must be provided for the residents of Orleans for review.

Mr. David Farquhar also read a letter which he submitted for the record. He spoke about the cost of the CWMP and the planned Technical Review & Cost Analysis. He discussed the impact of the CWMP on the taxpayers and the more realistic cost of the plan is around $250 million rather than the estimated $150 million. He talked about the Town's demography and economy and its inability to handle a 165% increase in taxes and fees and the potential decrease in population as a result of this increase. Mr. Farquhar asked the subcommittee not to approve the CWMP until the results of the Technical Review & Cost Analysis are released.

Mrs. Vicki Reis addressed statements made by Mr. Meservey. Mrs. Reis stated that the residents were told through the press and at the meeting in 2008 that it was not the final plan and that the final plan would be voted on at a future date and it never came. Since that time, she noted that the population has significantly decreased and the Town is down to one precinct. She submitted a newspaper article for the record which discusses the vote. She asked that a

petition requesting that decentralized and alternative options be examined by the Town which has been submitted to the Board of Selectmen. She also submitted a letter addressed to the County Commissioners from the Town of Orleans in support of a study of the NAS review which demonstrates the need for information before the plan proceeds, as well as information from the Town website showing Namskaket restricted wetlands and shows that Namskaket Creek is an ACEC and noted that over a million gallons per day would be dumped into this area. She also submitted a portion of the draft CWMP where it states that in the suitability of treatment facility sites they had 5 bullets explaining the criteria to look for in choosing a site and she demonstrated how the chosen sites do not meet those criteria, and she included maps showing the proximity to nearby homes in the areas and stated that there are homes within 100 feet to the sites. Mrs. Reis stated that Secretary Sullivan assured the Town's residents that any outstanding questions would be answered during local permitting and thus far no questions have been answered. She submitted several other items for the record and asked that the process be halted until concrete data is provided.

Mr. Nello Trevisan also submitted a letter for the record which he read to the subcommittee. He spoke of the inadequacy of the estimated costs because of the stages involved in the CWMP and what that will do to taxpayers and the resulting population decrease. He then discussed the environmental impacts and the uncertainty surrounding where the plumes will transport the discharge and submitted email correspondence between himself and Dr. Weiskel of USGS. Finally he discussed the risk to future Conservation Trust donations. He summarized by stating that the Town should not be experimenting with a $150 million proposal.

Mr. Alan McClennen then read a letter that he wrote into the record and provided a copy for the subcommittee. He commended the subcommittee for their thoroughness in reviewing the CWMP and stated that he has followed the process from the beginning. He expressed his hope that the subcommittee will determine that the Orleans CWMP meets all the requirements for an acceptable DRI and stated his belief that the plan is consistent with the Cape Cod Commission's criteria for approval.

Mr. Putnam asked if there were any Federal, State or local officials who wished to speak. There were none.

Mr. Putnam asked for final comments from the Town and Commission staff.

Mr. Meservey then assured the Subcommittee that if the plan is to move forward, the Town of Orleans would work with the Town of Brewster in every way possible.

Mr. Cambareri made a final comment about the fact that the restoration of waters according to TMDLs is a requirement and the Town is trying to address this and follow the Federal Clean Water Act. He noted that the areas which are addressed in the CWMP have been listed by the State as impaired waters.

Mr. Putnam stated that the Subcommittee should be making their judgment based on the DRI itself and not the engineering aspects of the project.

Mr. Roy moved to continue the hearing and the record to May 27, 2011 at 10:00 AM, for closure at that time by a Commission Hearing Officer. Ms. Taylor seconded the motion, and it came to a unanimous vote.

Ms. Taylor moved to hold a Subcommittee meeting to June 9, 2011 at 1:00 PM. Mr. Virgilio seconded the motion and it came to a unanimous vote.

May 24, 2011 Subcommittee Meeting
The Subcommittee meeting scheduled for after the public hearing on May 24, 2011 was not held.

May 27, 2011 Hearing Officer
Ms. Adams acted as a Hearing Officer on May 27, 2011 10:00 AM at the Cape Cod Commission office and closed a pro-forma hearing and the record on the Orleans CWMP. No presentations, testimony or substantive action was taken on the project.

June 9, 2011 Subcommittee Meeting
Ms. Adams reviewed the findings for approval which she noted were reviewed in the February 22, 2011 Staff Report.

Mr. Putnam asked Ms. Adams what the difference is between a DCPC and an ACEC from the subcommittee's point of view because one of the marshes is an ACEC.

Ms. Adams stated that the Cape Cod Commission acknowledges Areas of Critical Environmental Concern because they are designated at the State level, but in terms of the specific criteria for approval of DRIs, consistency with an ACEC and/or its implementing regulations, is not a criteria for approval.

Ms. Adams noted a February 11, 2011 letter from George Meservey, the Orleans Town Planner, which stated that the project involves a municipal use which is allowed by right in all zoning districts, the treatment plant site is in a General Business District, the proposed facilities are permitted by the zoning bylaw, the project adheres to the zoning bylaw dimensional requirements, and the project is subject to Site Plan and Architectural Review Committees. She also noted alternate testimony in the record which states that a Town vote on the final CWMP and associated costs is required. Ms. Adams stated that the subcommittee will need to deliberate on whether the Orleans CWMP is consistent with the municipal development bylaws, and should take into consideration letters in the record from Mr. Carney on March 1, 2011, and Ms. Reis and Mr. Dunford sent on May 26, 2011. She noted that the subcommittee will also need to deliberate on the consistency of the project with the Local Comprehensive Plan (LCP), and drew the subcommittee's attention to the February 11, 2011 letter from George Meservey which makes note of Action Item CF27, which called for the Town to develop a wastewater management plan for the entire town, approval of the Single/Final EIR by MEPA which fulfilled this Action Item, and that the CWMP includes an action plan and implementation mechanisms. She stated that they should also consider the alternate testimony related to the Town vote on the final CWMP, its costs, and the impacts on the Town.

For Open Space, which Ms. Adams noted was largely addressed in the February 22nd and March 16th Staff Reports, MPS OS1.3 exempts municipal projects for municipal purposes from the provision of open space, and that the CWMP is just that. Again she noted the alternate testimony in the record that the subcommittee should consider which included a March 1st letter from Mr. Pluciennik, a March 21st letter from Mr. Trevisan, and a May 24th letter from Ms. Carney dealing with Box Turtles and Open Space, and the possible impacts to the George Hoffe Conservation Area. Ms. Adams stated that the subcommittee will need to deliberate on whether the project is consistent with MPS OS1.3. Ms. Adams then addressed Plant and Wildlife Habitat and directed the subcommittee's attention to the February 22nd, March 16th and April 8th Staff

Reports. She stated that the Tri-Town site is mapped as a Significant Natural Resources Area as it is Eastern Box Turtle habitat and review by Natural Heritage and Endangered Species Program (NHESP) is required. She noted that the plant layout was revised based on NHESP input to reduce clearing and grading and that NHESP has not made a final determination and will likely do so after the Commission review. If NHESP determines the upgrade of the Tri-Town plant results in a "take" of Eastern Box Turtle Habitat, they will require a Conservation Management Permit which will detail the mitigation measures. She again referred to the alternate testimony regarding the impacts to Box Turtles and George Hoffe Conservation Area. She stated that the subcommittee will need to deliberate on whether the project can be conditioned to be consistent with MPS WPH1.2, WPH1.3, WPH1.4, and WPH1.5.

For Wetlands, Ms. Adams noted the February 22nd, March 16th, and April 8th staff reports. She stated that wetlands or wetland buffers might be encountered during construction in areas not at the Tri-Town plant site. MPS WET1.3 allows for installation of utilities where there is no feasible alternative. Ms. Adams noted the March 31, 2011 letter from George Meservey where he stated that despite the fact that the Town is not required to provide open space, the Town will undertake wetland restoration efforts in those instances where the sewer lines may intrude on wetland buffers or wetlands and a Notice of Intent will be filed at the local level with the Conservation Commission.

Ms. Taylor asked if the Town of Orleans and the Town of Brewster Conservation Commissions will be notified.

Ms. Adams stated that she is referring to the Town of Orleans because the sewer lines and physical disturbance will be in Orleans. She said that the subcommittee will need to deliberate on whether the proposed project can be conditioned to be consistent with MPS WET1.1, WET1.2 and WET1.3.

For Coastal Resources, Ms. Adams noted the February 22nd, March 16th, and April 8th Staff Reports as they relate to direct disturbance from construction of sewer lines and infrastructure. She referred to the March 31, 2011 letter from George Meservey in which he stated that where work for the CWMP will occur within coastal Resources as identified by the RPP, the Town has identified measures to comply with Coastal Resources MPS which are laid out in Section 12 of the CWMP and identified in the Staff Reports. Ms. Adams stated that the subcommittee should also consider alternate testimony from Ms. Carney and Ms. Reis. She said that the subcommittee should deliberate on whether the proposed project can be conditioned to be consistent with Coastal Resources MPS that apply to construction impacts (MPS CR2.2, CR2.3, CR2.4, CR2.6, and CR3.1), as well as MPS CR2.8 as a new non-water dependent infrastructure that may be in Land Subject to Coastal Storm Flowage (LSCSF) but is public infrastructure and provides an overriding public benefit.

Archaeological Resources, Ms. Adams noted, was largely dealt with in the February 22nd and March 16th Staff Reports. She stated that MHC has reviewed the Tri-Town plant site and determined that significant archeological resources are unlikely to exist there and that an archaeological survey will be conducted to determine the presence of resources at the cluster plant sites. The Town is committed to conducting this survey during the preliminary design phase, she stated, and the scope of the work is described on pages 11-46 of the Single/FEIR. Ms. Adams noted a May 26, 2011 letter from Mary Hartley which stated that the Tri-Town site does have archaeological significance. The subcommittee should deliberate on whether the proposed project can be conditioned to be consistent with MPS HPCC1.3, she said. Ms. Adams noted that the February 22nd and March 16th Staff Reports also dealt with Historic Preservation

and that the CWMP states that any aboveground structures within the Old Kings Highway Historic District (OKHHD) would be designed consistent with the District Standards and MHC and OKHHD would review the structures. She also noted alternate testimony from Ms. Carney on March 1, 2011 asking when the Town will seek a Certificate of Demolition/Appropriateness from OKHHD. She stated that the subcommittee would need to deliberate on whether the proposed project can be conditioned to be consistent with MPS HPCC1.1 and HPCC2.4.

Ms. Adams stated that the February 22nd, March 16th and April 8th Staff Reports dealt with Transportation and the impacts to private roads from construction. Ms. Adams stated that at the March 23, 2011 meeting the subcommittee asked the Town whether the roads impacted by sewer line construction would be restored and the Town responded in a letter dated March 29, 2011 that they would. She also noted a March 8, 2011 memo from Wright-Pierce in the record which stated that vehicle trips are expected to be less than 25 in peak hour even after Tri-Town site is redeveloped into a wastewater treatment plant, that stopping sight distances at Overland Way are adequate, and that Commission staff verified Level of Service "A" at Overland Way under current and proposed conditioned, including all combinations of 25 turning movements. Alternate testimony from Mr. Amman on May 26, 2011 stated that use of STEP systems will result in different construction methods that will lessen or eliminate impacts to roads. Ms. Adams stated that the subcommittee will need to deliberate on whether the proposed project is consistent with MPS TR1.2, TR1.3, TR1.8 and TR3.1 in the area of Transportation.

Mr. Tom Cambareri provided a PowerPoint presentation and reviewed the applicable Minimum Performance Standards related to Water Resources and how they apply to the project. He covered twelve issue areas that he stated the subcommittee would need to deliberate on.

Mr. Roger Putnam asked if Namskaket Marsh will continue to be monitored for the movement of nitrogen loading.

Mr. Cambareri answered affirmatively and stated that he would go over that in more detail later in the presentation.

Mr. Cambareri then discussed the Storm Water standards and stated that each standard under this section applies to the project except for WR7.7, Structured Infiltration Devices in Economic Centers and WR7.11, Shut-off Valve in Wellhead Protection Areas.

Ms. Adams asked if this would apply to the Tri-Town Plant.

Mr. Cambareri answered affirmatively.

Mr. Cambareri then reviewed additional issues that have come up during public hearings, within the Staff Reports, and identified in the CWMP, beginning with the MEP science. He stated that the method is reviewed by DEP and EPA and the science program is a partnership with USGS, DEP, the Commission and private engineers using standard industry models. He stated that the findings are accepted by DEP and EPA for the establishment of TMDLs, and TMDLs and MEP Reports are recognized by the Regional Policy Plan under WR3.1. The CWMP, he said, confirms that the confirmatory MEP modeling will be part of the Preliminary Design.

Ms. Elizabeth Taylor asked Mr. Cambareri to clarify as to the meaning of confirmatory modeling.

Mr. Cambareri stated that the MEP has a service where they look at proposed nitrogen removal scheme within the watershed to run the models and confirm that the amount of nitrogen taken out results in a water quality parameter that meets the total maximum daily load in the embayment. There will be incremental periods where water quality will be monitored after each phase, providing a basis for the adaptive management plan, Mr. Cambareri said. He then went on to discuss Nauset Marsh, and stated that the CWMP uses a place holder of 55% septic nitrogen removal, and the average amount of nitrogen removal for the 28 completed MEP watershed reports is 51%. He said that MEP staff has acknowledged the place holder value.

Ms. Taylor asked if MEP agrees with the placeholder value or acknowledges it.

Mr. Cambareri stated that they agree with it.

Mr. Cambareri stated that the TMDL for Pleasant Bay water quality was established before the 2007 breach, which has improved water quality in Pleasant Bay. He noted that the water quality in head waters is still degraded and the CWMP focuses on cluster systems for several headwater locations and centralized sewers for Meetinghouse pond. Mr. Cambareri stated that the Wastewater Treatment Facility is not located in the Area of Critical Environmental Concern but is located adjacent to the boundary of it and noted that compliance with the ACEC is not a criterion for approval. In regards to the Namskaket nitrogen assimilative capacity, there is 67% excess nitrogen assimilative capacity presently, he said, and there will be 63% excess nitrogen capacity when the Wastewater Treatment Facility is built at its design flow. Under practical build out of 26% growth there will be 59% assimilative capacity, he said, and the existing freshwater inflow is 456 MGD. With the Wastewater Treatment Facility, the flow will be 496 MGD, an increase of 9% freshwater flow, and the existing salinity flowing from Hurleys Bog may be reduced by 25% from 2.4 to 1.8 ppt at low tide. The upper range of salinity is 30 ppt. Mr. Cambareri stated that groundwater monitoring will be required as a condition of the DRI and the DEP Groundwater Discharge Permit, and the process will provide for public input. Mr. Cambareri addressed the coliform issue and stated that Namskaket Marsh was first closed to shell fishing in 1987 when Cape-wide sampling programs began. He noted that the Tri-Town Plant began discharging in February 1990 and that coliform bacteria does not survive passage in groundwater systems. There are other sources of coliform in surface waters, he said.

In regards to regional opportunities, Mr. Cambareri noted that Brewster and Orleans met to discuss assimilative capacity and monitoring. The DRI would incorporate suggestions from Brewster about monitoring in the Namskaket Marsh. He stated that the Town of Brewster and the Town of Eastham generally support the CWMP so long as they are able to participate in the process. Mr. Cambareri noted that the Town has voted to undertake alternative analyses comparing technology and a decentralized approach and that the Town can accommodate changes in the Plan. Mr. Cambareri ended his presentation by going over the key points related to adaptive management.

Ms. Adams then presented two more slides in which she reviewed some of the potential benefits and detriments of the project, noting materials in the record. She stated that the subcommittee should deliberate on whether the probable benefit from the Orleans CWMP is greater than the probable detriment.

Based on the fact that there are no Districts of Critical Planning concern in Orleans, Ms. Taylor moved that the criterion of DRI approval is not applicable to the project. Mr. Roy seconded the motion and it came to a unanimous vote.

Based on the February 11, 2011 written testimony of George Meservey, Orleans Planning Director, Mr. Putnam moved that the proposed Orleans CWMP is consistent with Orleans local development bylaws. Mr. Virgilio seconded the motion and it came to a unanimous vote.

Mr. Roy moved that based on the February 11, 2011 written testimony of George Meservey, that the proposed Orleans CWMP is consistent with Orleans Local Comprehensive Plan. Ms. Taylor seconded the motion and it came to a unanimous vote.

Mr. Virgilio moved that based on the materials submitted to date, that the proposed project is a municipal project for municipal purposes, and as such, is exempt from Regional Policy Plan Minimum Performance Standard OS1.3 requiring the provision of open space. Ms. Taylor seconded the motion and it came to a unanimous vote.

Mr. Roy moved that based on the materials submitted to date, that the proposed project can be made consistent with the Regional Policy Plan Minimum Performance Standards WPH1.2, WPH1.3, WPH1.4 and WPH1.5 related to Plant and Wildlife Habitat through conditions. Mr. Virgilio seconded the motion and it came to a unanimous vote.

Ms. Taylor moved that based on the materials submitted to date, that the proposed plan can be made consistent with the Regional Policy Plan Minimum Performance Standards WET1.1, WET1.2 and WET1.3 related to Wetlands through conditions. Mr. Roy seconded the motion and it came to a unanimous vote.

Based on the materials submitted to date, Mr. Virgilio moved that the proposed project can be made consistent with the RPP Minimum Performance Standards related to Coastal Resources as they relate to project construction impacts, CR2.4, CR2.2, CR2.6 and CR3.1 through conditions. Ms. Taylor seconded the motion and it came to a unanimous vote.

Mr. Roy moved that based on the materials submitted to date, the proposed project is considered non-water dependent public infrastructure that may be in Land Subject to Coastal Storm Flowage, but is allowed per RPP MPS CR2.8 as there is an overriding public benefit and as the project is public infrastructure. Mr. Virgilio seconded the motion and it came to a unanimous vote.

Mr. Roy moved that based on the materials submitted to date, the proposed project can be made consistent with the RPP Minimum Performance Standards related to Archaeological and Historic Resources, HPCC1.3 through conditions. Ms. Taylor seconded the motion.

Mr. Virgilio asked for clarification as to how this will affect cluster plants sites.

Ms. Adams and the subcommittee discuss how the decision could be conditioned to require that there be archaeological surveying on potential sites.

The motion made by Mr. Roy on MPS HPCC1.3 passed unanimously.

Ms. Taylor moved that based on the materials submitted to date, the proposed project can be made consistent with the RPP MPSs related to Historic Resources as they relate to above-ground structures, HPCC1.1 and HPCC2.4 through conditions. Mr. Virgilio seconded the motion and it came to a unanimous vote.

Based on the materials submitted to date, Ms. Taylor moved that the proposed project is consistent with the RPP MPSs related to Transportation resources including TR1.2, TR1.3, TR1.8 and TR3.1. Mr. Virgilio seconded the motion and it passed unanimously.

Mr. Putnam moved that the DRI approval be conditioned upon the Town's willingness to restore roads impacted by sewer line construction to their original state.

The subcommittee's concerns about the roads were addressed by Mr. Meservey.

The motion made by Mr. Putnam was modified to include "public or private roads" and "original state or better."

Ms. Taylor seconded the amended motion and it came to a unanimous vote.

Ms. Taylor moved that based on the materials submitted to date, the proposed project is consistent with the RPP MPS WPH1.1 related to Plant and Wildlife Habitat for the Tri-Town Plant site. Mr. Virgilio seconded the motion and it passed unanimously.

The subcommittee meeting was continued to Wednesday, June 15, 2011 beginning at 5:00 PM at Brewster Town Hall.

June 15, 2011 Subcommittee Meeting

Ms. Andrea Adams provided an update on the project. She noted materials distributed to the Subcommittee at this meeting and said the Subcommittee should go over the Water Resources issue area, and determine whether or not the Subcommittee had enough information to make findings.

Mr. Cambareri, using copies of his PowerPoint presentation, described how the Orleans CWMP related to the applicable RPP Minimum Performance Standards (MPS). In the area of General Aquifer Protection, he noted the applicable MPS were WR1.1, WR1.2, and WR1.5. He noted that MPS WR1.3 and WR1.4 did not apply to the CWMP. In the area of Drinking Water Protection, he noted the applicable MPS were WR2.1 and that the rest of the MPS in this section did not apply to the project. In the area of Marine Water Protection/Restoration, Mr. Cambareri said all the MPS would apply to the CWMP except for MPS WR3.5. In the area of Fresh Water Protection/Restoration, Mr. Cambareri said that MPS WR4.1 and MPS WR4.3 applied to the Orleans CWMP, but not MPS WR4.2. In the Water Resources issue area dealing with Water Quality Improvement, he said that MPS WR5.1 and MPS WR5.2 applied, but not the rest of these MPS. In the area of Public and Private Wastewater Facilities, Mr. Cambareri said that MPS WR6.2, MPS WR6.3 and MPS WR6.4 applied to the project, as well as WR6.8 and WR6.9. He said that MPS WR6.1 as well as WR6.5, WR6.6 and WR6.7 did not. In the area of Stormwater Management, Mr. Cambareri said that all of the MPS in this section except for MPS WR7.7 and WR7.11 would apply to the Tri-Town Treatment Plant site redevelopment.

Mr. Cambareri then discussed potential findings for Water Resources. He noted that in Section WR1, MPS WR1.1 sets 5-parts per million (PPM) as a standard for nitrogen loading. He noted the wastewater treatment plant described in the CWMP would be designed to achieve 3 ppm. He noted this had been discussed in the January 11th and February 22nd staff reports. He said the Subcommittee should deliberate on whether or not the proposed Orleans CWMP is consistent with MPS WR1.1.

Ms. Taylor moved that based on the materials submitted to date, the proposed project can be made consistent with Regional Policy Plan (RPP) Minimum Performance Standard (MPS) WR1.1. Mr. Roy seconded the motion and it was approved unanimously.

Mr. Cambareri said the next MPS was MPS WR1.2 relative to identification of drinking water wells within a 400 foot radius of the facility. He noted this had been discussed in the January 11th and February 22nd staff reports. He said the CWMP included a screening analysis that evaluated a number of criteria, and that Mr. Meservey had indicated that there were no private wells adjacent to the facility within 400 foot and noted most of these areas were served by municipal water. He said the Subcommittee should deliberate on whether or not the proposed Orleans CWMP is consistent with MPS WR1.2.

Ms. Taylor moved that based on the materials submitted to date, the proposed project can be made consistent with RPP MPS WR1.2. Mr. Virgilio seconded the motion and it was approved unanimously.

Mr. Cambareri said that with respect to MPS WR1.5, this had also been dealt with in the 1/11/11 and 2/22/11 staff reports. He noted turf and landscape management plans would probably be drafted once design plans for the wastewater treatment plant were finalized, but suggested the project could be conditioned to require the submission of a turf and landscape management. He said the Subcommittee should deliberate on whether or not the proposed Orleans CWMP is consistent with MPS WR1.5.

Mr. Virgilio moved that based on the materials submitted to date, the proposed project can be made consistent with MPS WR1.5. Ms. Taylor seconded the motion, and it was approved unanimously.

Mr. Cambareri said Water Resources section WR2 dealt with Drinking Water and noted MPS WR2.1 sets a 5ppm limit on nitrogen loading. He noted this had also been dealt with in the 1/11/11 and 2/22/11 staff reports. Mr. Cambareri said the facility is not located in a Wellhead Protection Area and that the Subcommittee should deliberate on whether or not the proposed Orleans CWMP is consistent with MPS WR2.1.

Ms. Taylor moved that based on the materials submitted to date, the proposed project can be made consistent with RPP MPS WR2.1. Mr. Virgilio seconded the motion, and it was approved unanimously.

Mr. Cambareri noted the design plans for the facility could be conditioned to address all the applicable stormwater management MPS. He directed the Subcommittee's attention to the staff reports and noted the Subcommittee should deliberate on whether or not the project is consistent with section WR7, including MPS WR7.1 to WR7.10.

Ms. Taylor moved that based on the materials submitted to date the proposed project can be made consistent with RPP MPS WR7.1 to MPS WR7.10. Mr. Virgilio seconded the motion, and it was approved unanimously.

For Fresh Surface Waters, Mr. Cambareri noted MPS WR4.1 and MPS WR4.3 dealt with limits on subsurface disposal relative to fresh water ponds, and the use of wastewater treatment. He said the CWMP identifies fresh water recharge areas to ponds, and includes a continued assessment. He noted the sewer would serve some residences in watersheds to fresh water

ponds. He said the Subcommittee should deliberate on whether or not the proposed Orleans CWMP is consistent with MPS WR4.1.

Ms. Taylor moved that based on the materials submitted to date the proposed project can be made consistent with RPP MPS WR4.1 and MPS WR4.3. Mr. Roy seconded the motion, and it was approved unanimously.

Mr. Cambareri said the next issue area dealt with Water Quality Improvement Areas. He noted the applicable MPS were WR5.1 and MPS WR5.2. He said the CWMP, which includes the centralized treatment facility and the proposed cluster treatment systems, would improve coastal water quality. He said the Subcommittee should deliberate on whether or not the proposed Orleans CWMP is consistent with MPS WR5.1 and WR5.2.

Mr. Virgilio moved that based on the materials submitted to date the proposed project can be made consistent with RPP MPS WR5.1 and MPS WR5.2. Ms. Taylor seconded the motion, and it was approved unanimously.

Mr. Cambareri discussed the MPS in the Coastal Water Quality section of the RPP. He noted the applicable MPS. On MPS WR3.1, Mr. Cambareri said that this was discussed in more detail in the 1/11/11 and 2/22/11 staff reports and slides. He noted the Subcommittee had also received testimony from the Town and the Town's consultants, as well as March 11, 2011 and March 23, 2011 letters. He noted the CWMP references the MEP reports and that the Subcommittee had been given a presentation by a representative of the USGS. He noted the CMWP dealt with major coastal embayments in Orleans, including Rock Harbor, Pleasant Bay, and Nauset Marsh, some of which are listed as impaired waters by the state, and said the Clean Water Act requires restoration of water quality in these embayments. He noted the MEP project had determined critical loads for these embayments, and that both the EPA and MADEP have established Total Maximum Daily Loads (TMDLs) for these embayments. He said the RPP recognizes the TMDLs and MEP Technical Reports. He noted there was a reasonable placeholder critical load for Nauset Marsh and the TMDL for Namskaket Marsh systems indicate it has excess capacity. He noted the alternate testimony received by the Subcommittee, including letters from Mr. Amman, Mr. Eagles and Mr. Daley. He said the Subcommittee should deliberate on whether or not the MEP science is appropriate to use as the basis of the project based on several factors which he listed, and on whether or not the MEP science is appropriate to use as the basis of the project's consistency with RPP MPS 3.1.

Mr. Virgilio asked Mr. Cambareri to clarify the relationship between a private contractor and the DEP.

Mr. Cambareri said the DEP is contracted with the School of Marine Science (SMAST), which is sub-contracted with a firm called Applied Coastal Sciences and explained their relationship to the subcommittee.

Ms. Taylor asked if things would change if updated science were used for the MEP or the Nauset Marsh placeholder value.

Mr. Cambareri replied that this motion was particular to the alternate testimony on the science related to MPS WR3.1.

Ms. Adams noted the Subcommittee had heard alternate testimony about this issue. She said the Subcommittee needed to decide which testimony was most persuasive to the Subcommittee.

She said if the MEP findings change, the question is, is it appropriate as a basis for MPS WR3.1. She also noted the Adaptive Management Plan.

Ms. Taylor asked whether the Adaptive Management concept was therefore applicable throughout.

Mr. Cambareri replied in the affirmative and said that the draft decision would have some specifics of the Adaptive Management Plan for the Subcommittee to evaluate.

Mr. Putnam expressed the same concern about Adaptive Management.

Ms. Adams said the conditions would describe the components of an Adaptive Management Plan. She said conditions are the manner in which the Commission tells an Applicant what to do.

Mr. Putnam asked about whether or not another Town vote was needed on the engineering aspects. Mr. Putnam noted the Subcommittee was looking at the components of a wastewater treatment plan in general, but that the choice of the final technology to meet the requirements would be up to the Town of Orleans.

Ms. Adams said there was testimony in the record that there was a warrant Article to look at STEP systems. She suggested the testimony from Mr. Meservey that the Town would look at using STEP systems, and if so, the Adaptive Management Plan would account for this.

Mr. Cambareri agreed with Ms. Adams.

Ms. Adams suggested the conditions would set the requirements for nitrogen loading, which was really the key driver. She also noted that all DRI applicants have the opportunity to seek a modification of the DRI decision. She said the question before the Subcommittee is whether or not the MEP science is appropriate to use as the basis of project consistency with RPP MPS 3.1.

Ms. Taylor moved that based on the materials submitted to date the MEP science is appropriate to use as a basis for the project for consistency with RPP MPS 3.1. Mr. Roy seconded the motion.

Mr. Putnam said he was satisfied that the presentations showed the consistency with current science standards and Mr. Virgilio and Mr. Roy agreed with Mr. Putnam.

Ms. Taylor asked about the other reviews, and testimony that the underlying models had not been released for public comment. She questioned if the motion would leave flexibility if the MEP science and model changed.

Mr. Cambareri said the Adaptive Management Plan (AMP) would account for this, including confirmatory modeling.

Mr. Putnam called for a vote on the motion, which passed unanimously.

On Nauset Marsh, Mr. Cambareri said the Subcommittee had received alternate testimony from Mr. Amman, Mr. Eagles and Mr. Daley that the Nauset Marsh study is not complete. He said the Subcommittee needed to deliberate on whether the project can be conditioned to accept the CWMP Nauset Marsh placeholder value of 55% for nitrogen removal, and that the average

nitrogen removal amount in the 28 completed Technical Reports is 51%. Mr. Cambareri also said that MEP staff has agreed that the placeholder value of 55% is appropriate, and that the MEP report for Nauset Marsh is due out summer 2011. He noted the CWMP sewer area could also be modified to account for this via the AMP.

Mr. Roy moved that based on the materials submitted to date the proposed project can be conditioned to accept the CMWP Nauset Marsh placeholder value for consistency with RPP MPS 3.1. Mr. Virgilio seconded he motion, and it passed unanimously.

On the issue of Pleasant Bay, Mr. Cambareri said the Subcommittee had heard testimony from Mr. Amman, Mr. Daley, Mr. Eagles and others that the water quality in Pleasant Bay is improving due to a breach in 2007 and does not warrant sewering in Orleans. Mr. Cambareri said that the Subcommittee needed to deliberate on whether the project and its objectives can be conditioned to account for the water quality uncertainty subject to the breach. He noted in this respect that the TMDL for Pleasant Bay was established pre-2007 breach, that the breach has improved water quality, but that it is still degraded in the headwaters of Pleasant Bay. He also noted the CWMP cluster systems are proposed for several headwaters locations and centralized sewer around Meetinghouse Pond. He noted that the general Pleasant Bay area sewering will occur in Phase 5 and is not scheduled for implementation until 2025. Based on this, Mr. Cambareri said monitoring would allow water quality information to be collected and input into the AMP. He noted that confirmatory modeling would also be required as a condition of DRI approval.

Mr. Putnam stated that around 20 years of monitoring would happen between 2011 and 2025.

Ms. Adams noted that MPS WR3.1 is the nitrogen loading standard. She said the breach does exist but the water quality that was there pre-breach is more conservative.

Mr. Roy said the conditions would allow the Town to look at the data, including the breach, whether it's there or not.

Mr. Putnam said he thought the breach might close in the next few years.

Mr. Cambareri said the DEP was of the position that the more conservative pre-breach water quality conditions should be looked to as the baseline.

Mr. Roy said the proposed motion acknowledges this, and allows adjustments based on new data.

Mr. Roy moved that based on the materials submitted to date the proposed project can be conditioned to account for water quality uncertainty subject to the Pleasant Bay breach for consistency with MPS WR3.1. Ms. Taylor seconded the motion, and it passed unanimously.

Mr. Cambareri addressed the Coastal Water Quality MPS. He said that the Subcommittee needed to deliberate on whether the project can be conditioned to be consistent with MPS WR3.1, WR3.2, WR3.3, WR3.4 and WR3.6.

Mr. Virgilio moved that based on the materials submitted to date the proposed project can be conditioned to be consistent with MPS WR3.1, WR3.2, WR3.3, WR3.4 and WR3.6. Ms. Taylor seconded the motion and it passed unanimously.

For Private and Public Wastewater Treatment Systems, Mr. Cambareri noted several issues had come up in the course of the review, including the Pleasant Bay ACEC. Mr. Cambareri noted the Tri-Town plant site is not located in the ACEC, although it and the proposed upgraded wastewater treatment plant at the Tri-Town site is adjacent to the ACEC boundary, but that consistency with an ACEC is not a criterion for DRI approval.

Ms. Adams said that the draft written decision would include a finding acknowledging the ACEC.

Mr. Cambareri addressed the issue of the assimilative capacity of Namskaket Marsh. He noted the alternate testimony in the record from the Town of Brewster and others that the assimilative capacity of the Marsh will be used up, and that there is no mechanism to allocate this capacity. Mr. Cambareri said that the Subcommittee needs to deliberate on whether there is assimilative capacity to accommodate nitrogen from the proposed project based on staff reports and other testimony that showed that there is a 67% excess capacity in the Marsh presently, that there will be 63% excess capacity when the wastewater treatment plant is built at its design flow, that under the practical build out of 26% growth, there will be 59% assimilative capacity and that regional input to monitoring and reporting will be required as part of the AMP.

Mr. Putnam asked if the agreement between Brewster and Orleans is recognized in this case or whether it needed to be included in the conditions of the decision.

Mr. Cambareri said there was no intermunicipal agreement per se but the Town of Orleans made a proposal to the Town of Brewster, and Brewster acknowledged the CWMP could go forward based on the outlines of the proposal being included in the decision relative to monitoring.

Ms. Adams noted the Orleans proposal to Brewster on 5/12/11 and a subsequent letter.

Ms. Taylor said it was hard to deliberate on the findings without having had the benefit of reviewing the outlines of the monitoring program.

Ms. Adams acknowledged this, but said the question for the Subcommittee was is there sufficient assimilative capacity in the Namskaket Marsh system to accommodate nitrogen from the project for consistency with MPS 3.4.

Ms. Taylor said the concept of assimilative capacity appears to entail that the load will be spread generally uniformly over a general area, when there may be breakouts at specific sites which could have different effects on the Marsh. She asked whether this would be included in the conditions.

Mr. Cambareri said the monitoring would include surface and groundwater monitoring as well as ecological monitoring.

Ms. Taylor said the entire Marsh could assimilate the nitrogen, but it may show up in specific parts of the Marsh, where assimilative capacity would be different.

Mr. Cambareri noted the assimilative capacity of the Marsh was really that of the creek that the Marsh discharges into. He said that flowing surface water has the capacity to accept that nitrogen.

Mr. Len Skidmore, Brewster Wastewater Committee, said the three sub-bullets on the slide being referred to by Mr. Cambareri are in conflict. He said the three points should be consistent.

Mr. Cambareri said the intent of the three sub-bullets was the same. He said these numbers came from the MEP technical team.

Mr. Putnam asked if the Commission could emphasize the need for a formal Memo of Understanding on this point.

Ms. Adams said the Subcommittee could do so through a finding in the decision and encourage the Towns to enter into a formal agreement.

Mr. Putnam said his concern was relative to jurisdiction over Namskaket Marsh.

Mr. Cambareri said this issue was potentially addressed in the idea of regional solutions.

Mr. Roy moved that based on the materials submitted to date, there is assimilative capacity in the Namskaket Marsh system to accommodate nitrogen from the project for consistency with MPS 3.4. Ms. Taylor seconded the motion, and it passed unanimously.

Mr. Cambareri discussed the issue area of fresh water assimilative capacity of the Namskaket Marsh and noted testimony that the additional fresh water flows to the Marsh from the proposed WWTP were significant, and would upset the ecology in the Marsh. Mr. Cambareri said the Subcommittee needed to deliberate on this and noted the existing fresh water inflow to the Marsh was 4.56 million gallons per day (MGD). He said with the proposed WWTP, the freshwater flow would be 4.96 MGD, an increase of less than 9% of the freshwater flow. He said the existing salinity from Hurley's Bog may be reduced by 25% from 2.4 to 1.8 parts per thousand at low tide. He said the upper range of salinity is approximately 30 parts per thousand. He also noted the tidal prism is 147 MGD compared to 0.64 MGD for the WWTP. He said the freshwater flow is relatively small to these factors in the Marsh system.

Ms. Taylor said the freshwater flow is not going to be spread out and it may have breakouts or change the Marsh habitat. She said perhaps it may not be significant for hydrologic balance.

Mr. Cambareri acknowledged Ms. Taylor's concerns, but suggested that the issue is one of hydrological balance in terms of volume and salinity.

Ms. Taylor said it would help to tie the motion to hydrologic balance.

Mr. Putnam noted that if there was a breakout, that would be an indication that the AMP needed to be updated.

Mr. Putnam asked that the proposed draft motion be reworked to more closely mirror the issue in MPS WR6.3.

Mr. Cambareri addressed the issue of coliform contamination and closure of shellfish beds. He noted the alternative testimony and stated that the subcommittee would need to deliberate on whether the coliform bacteria problem at Namskaket would be exacerbated by the WWTF based on the materials submitted to date.

Ms. Taylor moved that based on the materials submitted to date, that the Coliform bacteria problem at Namskaket will not be exacerbated by the WWTF for consistency with RPP MPS 6.3. Mr. Roy seconded the motion and it came to a unanimous vote.

Mr. Virgilio moved that based on the materials submitted to date that the Wastewater Treatment Facility can maintain the hydrologic balance for the added freshwater flow from the proposed facility for consistency with RPP MPS WR6.3. Ms. Taylor seconded the motion and it was approved unanimously.

Mr. Cambareri went on to discuss groundwater monitoring and noted that it will be required as a condition of the DRI and the DEP GDP. The process, he said, will provide for public input of the GWDP and specifics will be developed as part of the Adaptive Management Plan scope of work. He noted that the same applies for the TMDL compliance and ecological monitoring.

Ms. Taylor asked whether development density units and a growth neutral policy would be referenced in the conditions of the decision.

Mr. Cambareri replied that it is part of the plan and will be recognized in the findings.

Mr. Meservey confirmed Mr. Cambareri's statement.

Mr. Virgilio moved that based on the materials submitted to date, that the proposed project can be made consistent with the RPP MPS under Section WR6, including MPS WR6.2, 6.3, 6.4, and 6.8. Mr. Roy seconded the motion and it was approved unanimously.

Mr. Cambareri noted that Brewster and Orleans met to discuss assimilative capacity and monitoring and that the DRI would incorporate suggestions from Brewster about monitoring in the Namskaket marsh. He stated that the Town of Brewster and the Town of Eastham generally support the CWMP with the option to participate. He also noted that alternative testimony stating that the CWMP process will preclude regional shared solutions. He said the subcommittee should deliberate on whether the project accommodates and allows for regional shared solutions.

The subcommittee expressed their concerns related to addressing the fact that Namskaket is a shared resource and directed staff to include findings that reflect those concerns and encourage cooperation between the towns.

Mr. Virgilio moved that based on the materials submitted to date, the proposed project accommodates and allows for regional shared solutions. Mr. Roy seconded the motion and it came to a unanimous vote.

Mr. Cambareri noted the alternative testimony in the record which states that the CWMP does not include alternative technology solutions or provide for a rigorous side by side analysis. He said that the subcommittee will need to deliberate on whether the CWMP includes alternative technology solutions and can be conditioned to allow for changes based on the CWMP including centralized and decentralized technologies, the Town's vote to undertake Alternative Analysis comparing technology and decentralized approach and the fact that changes in the plan can be accommodated under conditions.

Mr. Roy moved that based on the materials submitted to date, the proposed project includes alternative technology solutions and can be conditioned to allow for changes in the plan's implementation. Mr. Virgilio seconded the motion and it was approved unanimously.

Mr. Cambareri then addressed the adaptive management component of the plan and stated that the subcommittee will need to deliberate on whether the CWMP allows for changes in the course of its implementation based on a prescribed adaptive management plan that will track and provide for changes by including requirements for implementation of the plan and milestones, documentation of capital expenditure, compliance with the groundwater discharge permit, reporting on Estuary water quality monitoring, a summary of habitat assessments that may be completed by the town, Mass DEP and others, non-structural alternative progress, and potential evaluations and changes as needed. He also noted the alternative testimony in the record.

Mr. Roy moved that based on the materials submitted to date, the proposed project can be made consistent with the RPP MPS through the Adaptive Management Plan that allows for changes in the course of its implementation. Ms. Taylor seconded the motion and it came to a unanimous vote.

Ms. Adams noted that the last finding for approval of a DRI is that the probable benefits of the project outweigh the probable detriments and she stated that this was discussed in the staff reports. She noted that the CWMP is the creation of new public infrastructure and there is a long term benefit of that which is acknowledged in the Coastal Resources section of the RPP, and she noted alternative testimony in the record which states that it is uncertain whether the detriments will outweigh the benefits of this project.

Mr. Virgilio stated that based on the testimony received to date, he feels that the probable benefits do outweigh the probable detriments and Mr. Roy agreed.

Mr. Virgilio stated that the improvement in the nitrogen level in the embayments and Namskaket Marsh, Little Namskaket, Namskaket Creek and Rock Harbor is a benefit. He said the project will limit sewage from cesspits and septic systems to groundwater, and there will be betterments to aquaculture and shellfish in the Town Cove, Ayres Pond and Meetinghouse Pond, which are also benefits of the project.

Ms. Taylor asked whether one of the first things will be to implement alternative systems in the ponds.

Mr. Cambareri stated that it is scheduled for Phase 2, but they are discussing the possibility of moving it up to Phase 1.

Ms. Taylor stated that cleaning up those ponds would be a benefit of the project.

Mr. Virgilio stated that he would like to see some language in the decision which ensures that the sewage to groundwater from cesspits and septic systems is limited by the plan, as stated by Mr. Putnam.

Mr. Cambareri stated that it is a local requirement.

Mr. Virgilio moved that based on the materials submitted to date, that the probable benefits of the proposed development are greater than the probable detriments as the project is public

infrastructure, there will be improvement in various water bodies as a result of the project, including an improvement in nitrogen levels, it will limit sewage to groundwater, and there will be betterments to aquaculture and shellfish in places such as Town Cove, Ayres Pond, and Meetinghouse Pond. Mr. Roy seconded the motion and it was approved unanimously.

Mr. Virgilio moved to direct Commission staff to draft a written decision with conditions for review and approval for the Orleans CWMP. Mr. Roy seconded the motion and it was approved unanimously.

Ms. Taylor moved to continue the subcommittee meeting to July 7, 2011 at 4:30 PM at the Assembly of Delegates Chamber at the 1st District Courthouse in Barnstable. Mr. Virgilio seconded the motion and it came to a unanimous vote.

July 7, 2011 Subcommittee Meeting

Ms. Taylor moved to approve the draft minutes of June 15, 2011. Mr. Roy seconded the motion and it came to a unanimous vote.

Mr. Putnam invited Mr. George Meservey to present his request to the subcommittee.

Mr. Meservey stated that the Town of Orleans Board of Selectmen would like some time to review the draft decision, noting that the implications are long term in nature and significant to the Town, they felt that it was important to understand the terms and conditions of the decision and request a 60-day extension of the regulatory timeframe for a decision.

Ms. Wielgus noted that Section 13 of the Commission Act allows the Commission to grant the extension of the decision period, and by delegation of Chair, Mr. Putnam has the authority to sign on behalf of the Commission to sign the extension agreement, which would extend the decision period until September 22, 2011. She noted that it has already been signed by John Kelley on behalf of the Town and has been notarized. She presented the Agreement to Mr. Putnam for discussion.

Ms. Taylor moved to sign the extension agreement and extend the decision period to September 22, 2011. Mr. Roy seconded the motion.

Mr. Putnam asked Mr. Meservey whether the decision by the Town to study other possible forms of sewage collection impinges on the decision being made today.

Mr. Meservey replied that it did not. He stated that it was a separate study authorized by the Town Meeting to look at an alternative collection system, and should that study result in substantial changes to the CWMP, the Town would come back with a request to modify the decision and he believes it has been stated in a Water Resources Condition of the draft decision. He said this extension is for the purpose of the Board of Selectmen understanding the language of the decision.

Ms. Taylor's motion was approved unanimously and the extension agreement was signed by Mr. Putnam, Subcommittee Chair. The meeting adjourned at 4:46 PM.

September 27, 2011 Subcommittee Meeting

Mr. Putnam opened the subcommittee meeting at 2:05 PM. He noted it was being recorded, and as a meeting, was not designed for testimony.

Mr. Virgilio moved to approve the draft 6/9/11 subcommittee minutes as presented. Ms. Taylor seconded the motion, and it was unanimously approved.

Mr. Roy moved to approve the draft 7/1/11 subcommittee minutes as presented. Mr. Virgilio seconded the motion, and it was unanimously approved.

The subcommittee, together with Commission staff, reviewed a 9/16/11 draft decision document for the Orleans CWMP. Various spelling and other text corrections were made.

Mr. Putnam asked Commission staff to focus on the changes in the 9/16/11 draft that had been made from a 7/1/11 draft written decision.

Mr. Cambareri and Attorney Patty Daley, the Commission's Deputy Director, went over the 9/16/11 draft decision document, noting changes that had been made since the 7/1/11 draft. Ms. Daley noted that some of the changes were adding language to findings or conditions, or moving unchanged blocks of text from one area of the draft decision to another.

Ms. Adams noted the General Findings and Conclusions deal with the criteria for DRI approvals.

Mr. Cambareri and Attorney Daley went over the draft Water Resources conditions in detail.

Ms. Taylor questioned why the Town of Brewster had not been formally included on the Technical Review Committee (TRC) mentioned in several of the Water Resources conditions. She expressed concern that the Town of Orleans was using the Town of Brewster's marsh, without consulting the Town.

Mr. Cambareri said the decision had been drafted to respond to concerns raised at the public hearings, including those in a letter by Ms. Hughes. He noted a meeting had been held with Orleans and Brewster representatives, and Commission staff, in May 2011. He said the findings noted the marsh had absorptive capacity to accommodate the project. He noted conditions WRC14-WRC16 in particular with respect to including Brewster's concerns.

Ms. Taylor moved that a representative from the Town of Brewster be included on the TRC. Mr. Roy seconded the motion.

Mr. Roy suggested that Eastham, although it did not share part of the marsh, should also be included on the TRC.

Ms. Taylor amended her motion, and moved that a representative from both Brewster and Eastham be included on the TRC. Mr. Roy seconded the amended motion.

Mr. Cambareri noted condition WRC16 specifically included Brewster in the Groundwate Discharge Permit and biological monitoring components. He suggested there were some parts of the CWMP implementation that should remain with Orleans. He described the components of an AMP, noting that the Town of Orleans had 1-3 years to complete the final AMP and implement it. He suggested this would give time for Brewster to be involved.

Mr. Putnam acknowledged Mr. Meservey to comment.

Mr. Meservey said the Towns of Orleans, Brewster and Eastham had worked together for some time. He suggested the issue of discharge to the marsh was dealt with by condition WRC16. He said the Orleans Board of Selectmen had not yet taken a final position on the draft decision, but suggested the Town would be comfortable with Brewster having input on the biological monitoring components.

Attorney Daley noted condition WRC16 was not new; it was in the 7/1/11 draft decision.

Ms. Taylor said that based on Attorney Daley's comment, she was not certain why the Town of Brewster had sent the 8/16/11 letter to the Commission, requesting representation on the TRC.

Mr. Virgilio said he was a strong proponent of regional solutions, and Towns working together, particularly in the area of wastewater management, but he expressed strong reservations about another Town having the ability to prevent Orleans from moving forward with its CWMP. He noted that Orleans Town Meeting would have to make critical funding decisions in the future.

WRC10. Mr. Cambareri suggested condition WRC16 could be amended to read *"the Town of Orleans shall consult with and include the Town of Brewster as part of the Namskaket Creek Monitoring requirements for the Adaptive Management Plan and Ground Water Discharge Permit (GWDP) and provide draft and final GWDP applications to the Town of Brewster."* (Emphasis added so suggested edit can be seen) He suggested adding the words *"and include"* might address Ms. Taylor's and Mr. Virgilio's concerns. He said the intent was to keep Brewster involved in the monitoring components of the TRC.
Ms. Taylor said a red-line comparison of the two documents, with the changes clearly shown, would be very helpful.

Mr. Putnam acknowledged Mr. Sims McGrath to comment.

Mr. McGrath acknowledged Brewster's desire to be involved, in that maintaining communication between the Towns was vital. He suggested that condition WRC16 be amended in such a way as to have Brewster and/or Eastham have a non-voting representative on the TRC. He said this would allow them to be involved, but that Orleans would retain the final vote, particularly with respect to matters of funding.

Attorney Daley said Commission staff could create a few options for the wording of condition WRC16 or others, to address the concerns being discussed.

Mr. Putnam asked Ms. Taylor and Mr. Roy if they would withdraw their motion and second to allow Commission staff to work on draft language.

Ms. Taylor and Mr. Roy withdrew the motion and second from consideration.

Commission staff reviewed the remainder of the draft decision, including Findings and Conditions in all the covered Regional Policy Plan issue areas mentioned.

Ms. Taylor asked if the 7-year timeframe on a DRI decision was sufficient for the Town to implement the CWMP.

Attorney Senatori said that seven years is the time in which a DRI Applicant has to pull local permits with respect to an approved DRI decision. She said if this is done, the DRI decision then runs with the land for the duration of the project, no matter how long. She noted the

Commission has provisions to allow up to a five year extension of DRI decision where permits have been obtained within the timeframe.

Attorney Daley noted that the draft decision sets certain milestones, including for involvement of Brewster in the WWTP by the year before the 7 year timeframe would end.

Mr. Putnam asked what the next steps would be.

Ms. Adams said it would be advisable to have another subcommittee meeting to review a revised draft decision.

Mr. Meservey said the Board of Selectmen was scheduled to review the draft decision in early October.

Ms. Taylor said the Brewster Board of Selectmen may also want to provide more comments.

Mr. Roy moved to hold another subcommittee meeting on October 7, 2011 beginning at 9:00 AM at the Commission's office for the purpose of reviewing the draft decision. Mr. Virgilio seconded the motion, and it was unanimously approved.

Mr. Virgilio moved to adjourn the meeting. Mr. Roy seconded the motion, and it was unanimously approved. Meeting adjourned at 4:40 PM.

October 7, 2011 Subcommittee Meeting

Mr. Putnam opened the meeting at 9:00 AM. He asked Attorney Senatori to introduce the draft written decision.

Attorney Senatori said that the version of the draft written decision before the Subcommittee showed changes to the draft decision since the Subcommittee's last meeting in July 2011. She said that Mr. Cambareri would also discuss the changes in the Water Resources sections in more detail.

Mr. Cambareri went over the changes, beginning on page #5. He noted typographical errors and corrections.

Ms. Taylor noted a change to WRF12 on page 10 of the draft written decision. She noted these were numbering corrections.

Mr. Cambareri noted many of the changes in the document were unintentional, in that the merging of July and current draft decision lost some of the numbering of findings or conditions. He noted that on page #17, WRF47 had not changed. He noted that discussions with Orleans' consultants, there had been a slight change in the percentage amounts in WRF38 on assimilative capacity. Mr. Cambareri continued to go over other typographical errors on page #21. He said on page #31, the findings noted the Adaptive Management reports would be in two-year increments. He noted Finding WR15 added language concerning a Town representative from Brewster on the Technical Review Committee as an ex-officio non-voting member as described in the Adaptive Management Plan Scope which is also included as an Exhibit to the DRI decision. He noted certain studies would be done in the Preliminary Design phase. Mr. Cambareri noted the draft decision showed how the Coastal Resources section had been condensed.

Attorney Senatori distributed to the Subcommittee a copy of a letter from the Association to Preserve Cape Cod (APCC) received by the Cape Cod Commission on October 6, 2011.

Mr. Virgilio asked if anyone was present from the APCC to address comments to the Subcommittee or the letter?

No one from the audience responded.

The Subcommittee took time to read the letter.

Mr. Putnam asked if the record was closed, and as such, could the Subcommittee consider the APCCs letter?

Attorney Senatori said the Subcommittee could consider it as part of the final hearing on the draft written decision.

Attorney Daley said the APCC had a new Executive Director, Ed DeWitt. She suggested this may have contributed to the letter's tardiness.

Ms. Taylor said APCC had commented on the project before.

Mr. Cambareri said the Commission's decision has not set any threshold on salinity, but rather has bracketed the knowledge about that issue and what the range of salinity could be. He said this would be part of the Adaptive Management Plan and the Massachusetts Department of Environmental Protection's Groundwater Discharge Permit for the project.

Mr. Virgilio asked if APCC had technical staff similar to the Commission?

Mr. Cambareri said APCC had a group of volunteers who helped do coastal monitoring.

Ms. Taylor said the Commission does not conduct coastal marsh monitoring, and APCC does do this type of work.

Mr. Cambareri said this is the first time he had seen APCCs information. He said the information from APCC is that could be part of the Technical Review Committee's discussions.

Mr. Virgilio asked if APCCs comments needed to be incorporated into the draft decision?

Mr. Putnam suggested this could be part of the discussions of the Technical Review Committee (TRC). He noted the TRC now would include a Brewster representative. He said the map of Pleasant Bay in the decision should be more current.

Mr. Cambareri said the map in the draft decision was chosen because it shows the sampling stations.

Mr. Putnam acknowledged this, but suggested the map should be updated.

Mr. Cambareri said the sampling stations have not changed. He said the intent of the graphic was to show the sampling stations, not Pleasant Bay.

Mr. Putnam asked Ms. Taylor if she felt the changes in the decision addressed Brewster's concerns?

Ms. Taylor said yes. She said it had been discussed by the Town, and including Brewster on the Technical Review Committee was a positive step.

Mr. Putnam asked Mr. Roy and Mr. Virgilio if they were satisfied with the draft decision?

Mr. Virgilio and Mr. Roy said yes.

Mr. Roy moved to approve the proposed Orleans Comprehensive Wastewater Management Plan as a Development of Regional Impact with conditions. Ms. Taylor seconded the motion. The motion was passed unanimously.

Attorney Senatori said the Subcommittee should make a motion on the proposed project. She said the next motions should be on the draft decision, and to forward the document for consideration to the full Commission.

Mr. Virgilio moved to approve the draft written DRI decision, as amended, for the Orleans Comprehensive Wastewater Management Plan, and to recommend its approval by the full Commission. Mr. Roy seconded the motion. The motion passed unanimously.

Attorney Senatori noted the proposed project and draft decision had been noticed for consideration by the full Commission at the October 13, 2011 Commission meeting.

Mr. Virgilio asked if the agenda for October 13, 2011 was long?

Attorney Senatori said there were several agenda items.

Mr. Putnam suggested the discussion of the Orleans CWMP might be lengthy. He also suggested that testimony could be subject to a time limit.

Mr. Meservey asked if the Town should be prepared to make a presentation?

Mr. Putnam suggested the presentation at the full Commission meeting would be largely on the draft decision, and would be primarily given by Commission staff, but that the Town should be prepared to answer questions and to possibly make a short presentation.

Ms. Taylor moved to adjourn. Mr. Virgilio seconded the motion, and it was unanimously approved. Adjourned at 9:25 AM.

FINDINGS

General

GF1. The Commission finds that the applicant is the Town of Orleans.

GF2. The project is the Comprehensive Wastewater Management Plan for the Town of Orleans, as described in the Single Final Environmental Impact Report (SFEIR) of December 2010. The project consists of one centralized wastewater treatment facility and five cluster treatment systems with sewer extensions to restore water quality to impaired coastal embayments.

GF3. The first substantive Development of Regional Impact public hearing on the CWMP was held on March 1, 2011 where the project was reviewed for consistency with the 2009 Regional Policy Plan (*revised May 2010, effective June 2010*).

GF4. The written testimony of Mr. George Meservey, Orleans' Director of Planning and Community Development in a February 11, 2011 letter states *"Action Item CF-27 (of the Orleans Local Comprehensive Plan) recommends the Town develop a wastewater management plan for the entire town."* This letter also notes approval of the CWMP and Single/Final EIR by the MEPA office in January 2011 essentially completed item CF-27. The letter also notes that the CMWP includes recommended action related to plan implementation and development of an administrative structure related to oversight of operations (Action Items CF-28 and CF-34), and that the Town has begun these actions through the Board of Water and Sewer Commissioners. Based on this written testimony, the Commission finds the Orleans CWMP to be consistent with Orleans' Local Comprehensive Plan.

GF5. The February 11, 2011 letter from Mr. George Meservey, Orleans' Director of Planning and Community Development states that as a municipal use, the CWMP is allowed by right in all zoning districts. His letter also notes *"[t]he proposed treatment facility site...is within the General Business District"* and that *"[t]he facilities proposed would be permitted by the Zoning Bylaw."* Mr. Meservey's letter notes that facilities, including pump stations, will need to adhere to dimensional requirements in the Zoning Bylaw, and would be subject to both the Site Plan Review and Architectural Review Committees. Based on this written testimony, the Commission finds the Orleans CWMP to be consistent with Orleans' local zoning.

GF6. Based on the materials submitted for the record, the Commission finds that there are no Districts of Critical Planning Concern in Orleans and therefore it is consistent with this criterion.

GF7. The Commission finds that the proposed project is located within the Pleasant Bay and Cape Cod Bay Areas of Critical Environmental Concern (ACEC), but that the Plan takes steps to ensure that activities in or impacting on the areas are carried out so as to minimize adverse effects on marine and aquatic productivity, surface and groundwater quality, habitat values, storm damage prevention or flood control, historic and archaeological resources, scenic and recreational resources, and other natural resource values of the area in accordance with 301 CMR 12.2(1)(c) of the Executive Office of Environmental Affairs.

GF8. As described in the Final EIR, the benefits of the Comprehensive Wastewater Management Plan include: public infrastructure for the protection of public health; improvement of the water quality in the aquifer and restoration of marine water quality to meet federally adopted TMDLs for nutrients. The detriments are limited to construction activities and the length of time required to implement the plan. Based on the materials submitted for the record, the Commission finds that the probable benefit of the proposed development is greater than the probable detriment.

GF9. The Commission finds that the project will be implemented in accordance with the Final Comprehensive Wastewater Management Plan/Final Environmental Impact Report of December 2010, incorporated herein by reference. The Commission finds that any deviation from the CWMP/FEIR that affects TMDL compliance or otherwise changes or impacts the conditions of this decision will be reviewed as a modification of this decision in accordance with the Commission's Enabling Regulations in effect at that time.

Water Resources Findings

WRF1. The project affects the following water resources areas of the Regional Policy Plan:

- WR1 General Aquifer Protection
- WR2 Drinking Water Protection
- WR3 Fresh Water Protection / Restoration
- WR4 Marine Water Protection / Restoration
- WR5 Water Quality Improvement Area
- WR6 Public and Private Wastewater Facilities
- WR7 Storm Water

WRF2. Applicable water resources minimum performance standards are:

WR1.1, WR1.2, WR1.5
WR2.1
WR3.1, WR3.2, WR3.3, WR3.6
WR4.1, WR4.3
WR5.1, WR5.2
WR6.2, WR6.3, WR6.4, WR6.9
WR7.1, WR7.2, WR7.3, WR7.4, WR7.5, WR7.6, WR7.8, WR7.9, WR7.10

WRF3. The protection of drinking water is a major goal of the Regional Policy Plan (RPP Water Resources Goal WR2). The town of Orleans has been proactive in its efforts to protect its drinking water quality including: the adoption of a water resource protection district overlay and bylaw; acquired open space; performed required water quality sampling; constructed and operates a water treatment facility; and produces annual consumer confidence reports. Land use controls and regulations that have been adopted and implemented over the last 30 years have been effective in protecting the Orleans water supply. There are eight wells in Orleans. According to the 2009 Annual consumer confidence report the concentration of nitrate is very low ranging from Non-detect to 0.22 ppm. These concentrations are well below state and federal drinking water regulations and the Regional Policy Plan's MPS WR1.1 nitrogen loading standard of 5 ppm. Phase 5 sewering for nitrogen removal for Pleasant Bay that is also in the Well # 7 recharge area may provide additional benefits to drinking water quality. The Commission finds that the project is consistent with WR 1.1 nitrogen loading standards.

WRF4. Protection and restoration of the ecological integrity of fresh water ponds is a goal of the Regional Policy Plan (WR4). There are 63 fresh water ponds in Orleans. Commission finds that the Town of Orleans has undertaken significant actions through the Orleans Marine and Fresh Water Quality Task Force, concurrent with the CWMP/FEIR including an assessment of the status and management needs of its fresh water ponds. Orleans has been an active participant in the Cape Cod Ponds and Lakes Stewardship (PALS) project which Commission Water Resources staff coordinates. Information about Orleans Ponds was initially presented in the Commission's Cape Cod Ponds and Lakes Atlas of 2004. More recently PALS data from 18 ponds were reviewed and a detailed assessment was conducted on 5 ponds in the Commission's "Review and Interpretation of Orleans Freshwater Ponds Volunteer Data" report of 2007. Information from these detailed studies shows that these ponds span a continuum of ecological conditions. Bakers Pond is relatively pristine, although it has some deep-water conditions that warrant additional monitoring. Crystal Lake is relatively impaired, but most of the impairment is deeper in the pond and only occasionally are the impairments seen at the surface. Pilgrim

Lake and Boland Pond are impaired with regular mixing of internal sediment regenerated phosphorus prompting algae growth and near eutrophic conditions. The information provided in the Orleans CWMP indicates that connecting properties to sewer around Bolands, Crystal and Pilgrim Lake would provide an ecological benefit, but that for Bakers, Ice House and Shoal Pond more study is warranted regarding sewering of those area and that further study was warranted. The CWMP indicates that the Town will continue to monitor the conditions of its fresh water ponds. Continued implementation of Stormwater Management Plans will also address phosphorous and bacterial sources from runoff. Commission staff will continue to work with the town through their participation in the PALS water quality snap-shot as it is offered by the School of Marine Science and Technology at the University of Massachusetts at Dartmouth. The Commission finds that the project is consistent with MPS WR4.1 limiting new subsurface systems from the 300 foot buffer area and MPS WR4.3 the appropriate use of wastewater treatment facilities.

WRF5. The restoration and protection of the ecological integrity of marine waters is a major goal of the Regional Policy Plan (RPP Water Resources Goal WR3). Section 303(d) of the Federal Clean Water Act requires each state to (1) identify waters for which effluent limitations normally required are not stringent enough to attain water quality standards and (2) to establish Total Maximum Daily Loads (TMDLs) for such waters for the pollutants of concern. The TMDL "allocation" establishes the maximum loadings (of pollutants of concern), from all contributing sources, that a water body may receive and still meet and maintain its water quality standards and designated uses, including compliance with numeric and narrative standards. The Coastal systems are attached to the Adaptive Management Plan Scope, Exhibit A, appended to this decision and incorporated by reference, and listed below were identified by the state as impaired waters due to nitrogen loading, primarily from septic systems in their watersheds and bacteria from surface water runoff. For the purposes of the RPP, these embayments and their watersheds are considered impaired and water quality improvement is the Town's goal. The Commission finds the project is consistent with MPS WR 3.1 critical nitrogen load, MPS 3.2 maintenance or improvement of nitrogen loading, and MPS 5.1 water quality improvement nitrogen loading standard.

The following surface waters have been identified as impaired in Massachusetts Year 2010 Integrated List of Waters: Proposed Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act

Rock Harbor, Orleans Nutrients Q4 - 20081 Q2 – 20091
Nauset Marsh, Orleans/Eastham Nutrients Q2 – 20093 Q4 – 20093
Little Pleasant Bay (96933) MA96-78 Waters north and east of imaginary lines drawn from the northeasterly edge of Orleans (near The Horseshoe), southeasterly to the northeastern tip of Sipson Island, then continuing to and around the northeastern border of Sipson Meadow, Orleans then south to the northern tip of Strong Island, Chatham then east to a point on the inner Cape Cod National Seashore (excluding the delineated segments; The River, Pochet Neck, and Paw Wah Pond). 3.3 sq mi -Nutrients [10/24/2007-CN244.0]
Namequoit River (9661850) MA96-71 Headwaters, outlet Areys Pond, Orleans to confluence with The River, Orleans. 0.06 sq mi -Nutrients [10/24/2007-CN244.0]
Paw Wah Pond (96241) MA96-72 Orleans 0.01 sq mi -Nutrients [10/24/2007-CN244.0]

Namskaket Creek (9661375) MA96-27 From outlet of unnamed pond north of Route 6A in Orleans to mouth at Cape Cod Bay, Brewster/Orleans. 0.02 sq mi -Pathogens [8/28/2009-CN252.0]
Little Namskaket Creek (9661400) MA96-26 Source to mouth at Cape Cod Bay, Orleans. 0.01 sq mi -Pathogens [8/28/2009-CN252.0]

Town Cove (96929) MA96-68 Entire cove to Nauset Harbor, including Rachael Cove and Woods Cove, Orleans/Eastham 0.80 sq mi -Pathogens [8/28/2009-CN252.0]
Rock Harbor Creek (9661425) MA96-16 Outlet Cedar Pond, Orleans to mouth at Cape Cod Bay, Eastham/Orleans. 0.02 sq mi -Pathogens [8/28/2009-CN252.0]

WRF6. Orleans has been participating in the Massachusetts Estuary Project (MEP) including water quality sampling of its coastal waters and through participation in the Pleasant Bay Alliance and partnership with the National Park Service and Eastham. Where coastal systems are impaired, nitrogen loading critical thresholds are determined by the MEP. The MEP has provided Technical Reports for Pleasant Bay and the Orleans Northside Cape Cod Bay Embayments of Rock Harbor, Namskaket and Little Namskaket Creek. The Massachusetts Department of Environmental Protection (DEP) and federal Environmental Protection Agency (EPA) use the critical thresholds from the MEP to establish Total Maximum Daily Loads (TMDLs) according to the Federal Clean Water Act.

WRF7. The Commission finds that based upon the evidence submitted for the record, the MEP science is appropriate to use as the basis for the Comprehensive Wastewater Management Plan, and for determining consistency with MPS 3.1 for establishing critical nitrogen loads.

WRF8. The TMDL is the watershed management number from which the percent removal of wastewater nitrogen is calculated. The MEP results for the embayments surrounding Orleans indicate that removal of wastewater related watershed nitrogen loads should be 45 to 100 percent to achieve TMDL compliance. The relative percentage removal of nitrogen from septic systems is indicated in the Table 1 shown below. However, the Northside embayments including Namskaket and Little Namskaket Creek were found to have a much higher assimilative capacity of nitrogen due to their morphology and the tidal fluctuation of 9+ feet in Cape Cod Bay. Therefore nitrogen loads in those watersheds are well below a critical load and in fact there is excess capacity to assimilate additional loads to those waters as shown in Table 1.

TABLE 1 Percent septic nitrogen removal to restore water quality as determined by the Massachusetts Estuary Program

Pleasant Bay-TMDL % Removal	
Meetinghouse Pond	100%
Paw Wah Pond	75%
Pochet Neck	65%
Lonnies Pond	50%
The River	50%
Areys Pond	50%
Namequoit River	50%
Little Pleasant Bay	45%
Quanset Pond	50%
Pleasant Bay	50%

Northside Embayments –Draft MEP % Removal	
Rock Harbor	70%
Nauset Marsh – Estimated % Removal	
Nauset Marsh/Town Cove	55%
Excess Capacity over Existing Total Load-Draft MEP	
Namskaket Creek	261% Increase
Little Namskaket Creek	65 % Increase

WRF9. The MEP Technical Report for Nauset Marsh has been delayed and is not available. Based on a preliminary MEP appraisal the Town has decided to move forward with a placeholder percent removal of 55%. Earlier water quality studies on Nauset Marsh/Town Cove indicate that Town Cove is a sink for nitrogen causing anoxic conditions in its deep portions (Teal, et al, 1983). A review of 28 completed MEP Technical Reports indicates that the average amount of septic wastewater to remove to achieve water quality restoration goals is 51%. The CWMP indicates that the MEP technical staff supports the removal percentage. Commission staff has testified that the MEP technical staff concurred with this appraisal.

WRF10. The Commission finds that the proposed project can be conditioned to accept the CWMP Nauset Marsh placeholder value for consistency with Regional Policy plan MPS WR 3.1 critical nitrogen loading standard, MPS 3.2 maintain or improvement of nitrogen loading and MPS 5.1 water quality improvement nitrogen loading standard. The Commission further finds that when the MEP Technical Report for Nauset Marsh becomes available it will be applied through the Adaptive Management Plan as outlined in condition WRC1.

WRF11. Efforts to comply with the TMDL by reducing nitrogen loading within the watershed areas are projected to result in: 1) restoration of natural distribution of eelgrass as a habitat for shell and finfish, 2) prevent algae blooms, 3) protect benthic communities from impairment or loss, and 4) maintain dissolved oxygen concentrations that are protective of estuarine environments. The TMDL requires monitoring of marine water quality at sentinel stations as shown in the Adaptive Management Plan scope; Exhibit A, appended to this Decision and incorporated by reference, to provide for a primary measure of success of the CWMP goal to restore water quality.

WRF12. The TMDL provides nitrogen water quality targets as thresholds (mg/l) for those embayments in comparison to present observed nitrogen concentrations, as shown in the Table 2 below excerpted from the TMDL for the Pleasant Bay System and Tables VIII-4 and 5 excerpted from the Technical Reports for Rock Harbor, Namskaket and Little Namskaket Creek embayment systems.

WRF13. The completed MEP Technical Report for Nauset Marsh will inform the Town and Commission on the actual amount of nitrogen removal that will be required to achieve TMDL compliance for the Nauset Estuary. The information is critical to regional discussions relative to potential sewering in the Eastham side of the shared watershed and the extent of sewering in the Orleans portion.

Table VIII-4. Comparison of model average total N concentrations from present loading and the threshold scenario, with percent change, for the Namskaket Creek system. Loads are based on atmospheric deposition and a scaled N benthic flux (scaled from present conditions). The threshold station is shown in bold print.

Sub-Embayment	monitoring station	present (mg/L)	threshold (mg/L)	% change
Namskaket – mouth	WMO-22	0.421	0.637	+51.4%
Namskaket – lower	**WMO-23**	0.488	0.937	+92.2%
Namskaket – upper	WMO-24	0.662	2.054	+210.1%

Table VIII-4. Comparison of model average total N concentrations from present loading and the threshold scenario, with percent change, for the Little Namskaket Creek system. Loads are based on atmospheric deposition and a scaled N benthic flux (scaled from present conditions). The threshold station is shown in bold print.

Sub-Embayment	monitoring station	present (mg/L)	threshold (mg/L)	% change
Little Namskaket – mouth	WMO-19	0.604	0.749	+24.2%
Little Namskaket – lower	**WMO-20**	0.778	1.025	+31.8%
Little Namskaket – upper	WMO-21	1.044	1.412	+35.2%

Table VIII-5. Comparison of model average total N concentrations from present loading and the threshold scenario, with percent change, for the Rock Harbor System. Loads are based on atmospheric deposition and a scaled N benthic flux (scaled from present conditions). The threshold station is shown in bold print.

Sub-Embayment	monitoring station	present (mg/L)	threshold (mg/L)	% change
Rock Harbor Mouth	WMO-15	0.447	0.398	-11.1%
Rock Harbor Basin	WMO-16	0.574	0.454	-20.9%
Rock Harbor Marsh	**WMO-17**	**0.686**	**0.500**	**-27.1%**
Rock Harbor Creek	WMO-18	0.829	0.615	-25.8%

Table 2. Observed present nitrogen concentrations and target threshold nitrogen concentrations derived for the Pleasant Bay System

Subembayments (Sentinel Stations are in bold)	Sub-embayment Observed Total Nitrogen Concentration [1] (mg/L)	Sub-embayment Observed Bioactive Nitrogen Concentration (mg/L)	Target Threshold Bioactive Nitrogen Concentrations (mg/L)
Meetinghouse Pd (WMO-10)	0.72-0.98[2]	0.28-0.41[2]	0.21
The River-upper (WMO-9)	0.86	0.25	0.20
The River-lower (PBA-13)	0.56	0.18	0.17
Lonnies Pond (PBA-15)	0.78	0.28	0.21
Areys Pond (PBA-14)	0.73	0.30	0.25
Namequoit River (WMO-06)	0.73-0.83[2]	0.24-0.30[2]	0.21
The River-mid (WMO-08)	0.85	0.18	0.18
Pochet Neck (WMO-05)	0.72-0.84[2]	0.24-0.28[2]	0.21
Little Pleasant Bay (PBA-12)	0.57-0.77[2]	0.14-0.18[2]	0.16
Paw Wah Pond (PBA-11)	0.71	0.27	0.21
Quanset Pond (WMO-12)	0.56-0.60[2]	0.19-0.21[2]	0.21

WRF14. The information from Table 1 and the Nauset Marsh placeholder value was used by the Town of Orleans to develop a Phased Sewer Plan to attain the percent removals as required by the MEP studies and the TMDLs. The Orleans CWMP proposes a wastewater collection and treatment infrastructure to remove the component of nitrogen load emanating from the Orleans watersheds and a series of non-structural elements including: fertilizer control; stormwater management, water conservation program, flow and load reductions, enhancement of embayment flushing rates, and land use controls. The six phased sewer plan begins with the construction of wastewater treatment and discharge facilities and an initial trunk line sewer collection system to which subsequent collection phases will tie in as shown in Figure 1.

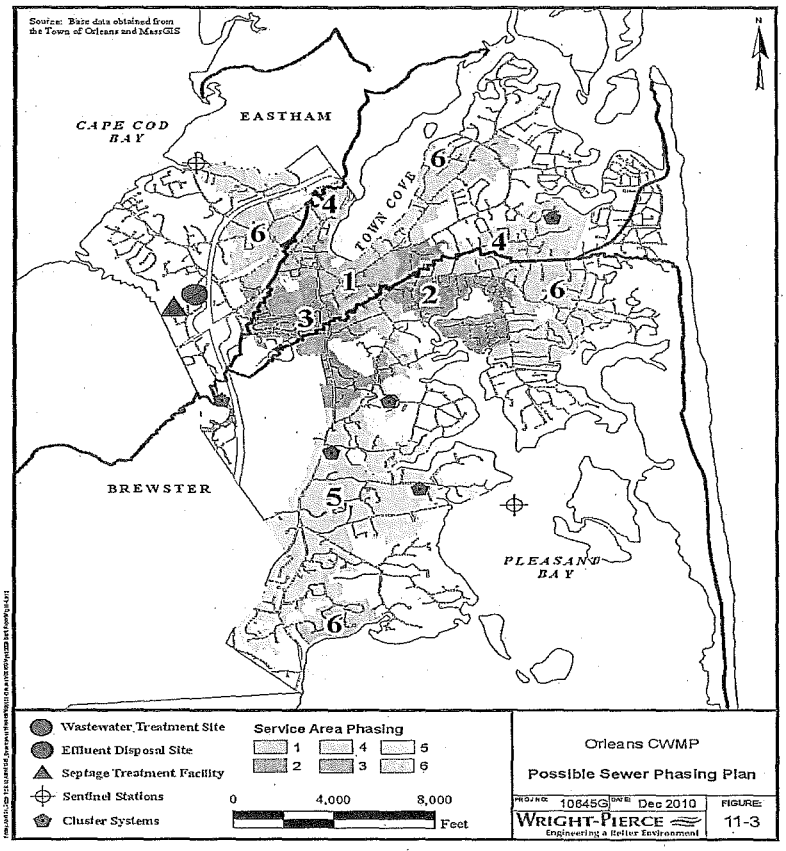


Figure 1 Orleans Sewer collection Phases

WRF15. Phase 1 of the plan (Figure 1) is planned to include the construction of the Wastewater Treatment Facility at the Tri-Town site and provide a sewer collection system primarily in the Nauset Marsh watershed. Phase 1 will collect approximately 130,000 gpd as an annual average basis, from 273 developed parcels. The collection area includes about 75% of the Village Center Zone and 75% of the portion of the Limited Business Zone that abuts Town Cove. It also includes some of the Limited Business Zone along Route 6A. Most of the Phase 1 collection area falls within the Nauset watershed, with the remainder in the Rock Harbor watershed. Sewering in Phase 1 will address 30% of the estimated nitrogen control need in the Nauset watershed and it will collect about two-thirds of the commercial district wastewater as shown on Figure 2. Phase 1 will address sanitary needs in 33 parcels (of the 198 town-wide), eliminate 2 tight tanks (of the 7 town-wide), and serve 18 parcels with a history of frequent septage pumping (of the 78 town-wide) of the town-wide aggregated needs also shown in Figure 2. Phase 1 does not

presently include areas already served by existing private cluster systems like those serving Skaket Corners.

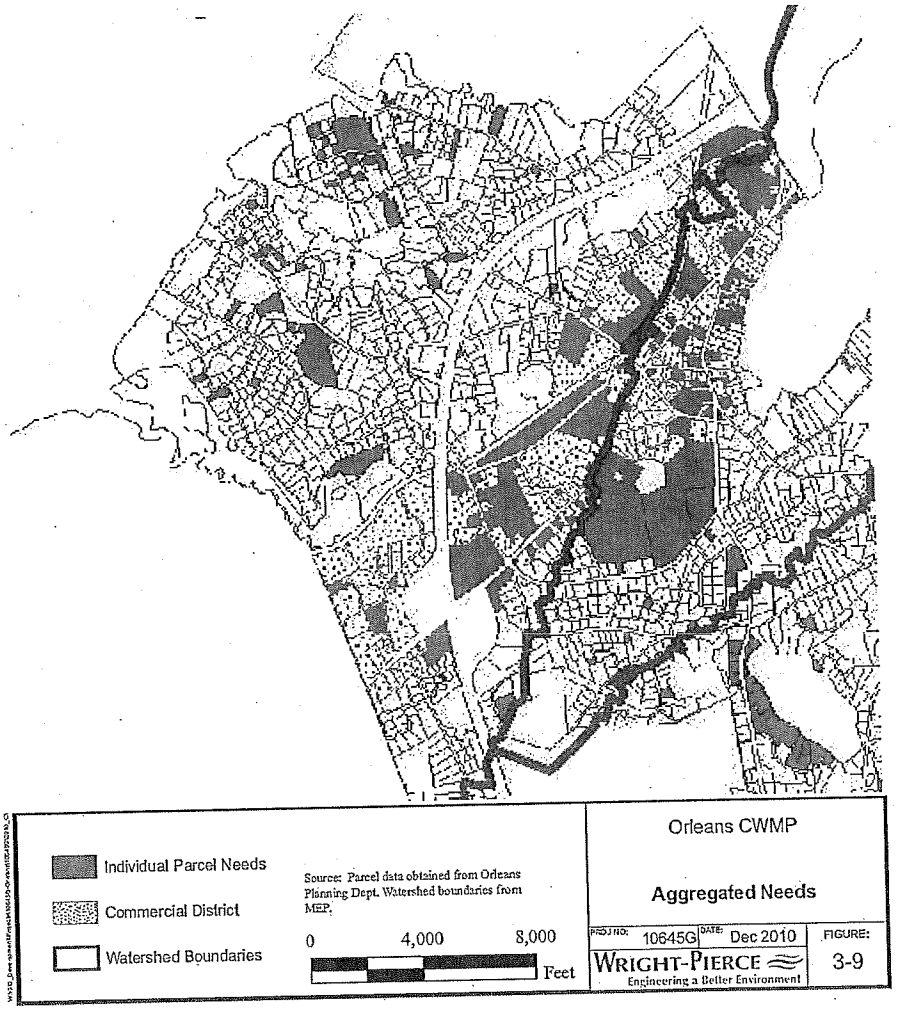


Figure 2 Aggregated Sewer Needs in the vicinity of the commercial Area

WRF16. The projected six phased sewer plan (Figure 1), as listed below is planned to be implemented over a 15 year period from the start of construction in 2015 to 2030 according to the updated schedule provided in the CWMP response to MEPA comments. Orleans has provided four years prior to construction to obtain funding to resolve outstanding issues within the Preliminary Engineering Design and subsequently obtain funds to begin construction.

- **Complete CWMP Early 2011**
- **Secure Preliminary Design Funds 2013 Spring**
- **Preliminary Design Resolutions and Engineering**
- **Secure Construction Funds 2015**
- **Phase 1 Construction 2015 to 2017**
- **Start-up of Phase 1 facilities mid 2017**

- **Phase 2 2018-2020**
- **Phase 3 2021-2023**
- **Phase 4 2024-2026**
- **Phase 5 2027-2029**
- **Phase 6 2030-2032**

WRF17. The attainment of percent nitrogen removals for TMDL compliance for the Orleans component of nitrogen removals will not occur until the end of Phase six in 2032 according to the Table 11-4 in the CWMP as shown below, unless non-structural and potential regional solutions allow earlier achievement.

TABLE 11-4
NUTRIENT LOAD REDUCTION BY PHASE

	Percentage of Required[a] Nitrogen Removal			
Phase	Pleasant Bay	Nauset System	Rock Harbor	Ponds [b]
1	<1	30	34	
2	24[c]	32	34	Bakers*, Reubens
3	31[c]	52	39	Crystal*, Boland's*
4	44[c]	86	49	Ice House*
5	80	86	49	Pilgrim*, Shoal*, Uncle Seths, Twinings
6	100	100	100	Cedar*, Uncle Harveys

Notes: (a) "Required" is based on Pleasant Bay TMDLs, Rock Harbor MEP technical report and preliminary Nauset estimates.
(b) * Denotes the first and second priority ponds identified in Table 3-4.
(c) Cluster systems represent about 10 percentage points in Phases 2, 3 and 4.

WRF18. Attainment of the total amount of nitrogen removal to meet the TMDLs and critical nitrogen loads for Nauset Marsh and Pleasant Bay will require that the Towns of Eastham, Brewster and Chatham also remove their watershed share of the nitrogen load or that Orleans provide more than its share of removal.

WRF19. The TMDL for Pleasant Bay was completed in May 2007 based upon the MEP Technical Report that used water quality data from 2000 to 2005. Since that time a major break has occurred in the Pleasant Bay barrier beach system that has increased flushing leading to water quality improvements in the major Pleasant Bay system. A study by the Cadmus Group entitled, *Pleasant Bay Alliance Water Quality Monitoring Program: Statistical Analysis of Multi-Year Water Quality Data* (2010), evaluated water quality over the last decade in the Pleasant Bay system. The study found statistical trends for decreasing water quality in the general Bay area prior to the 2007 break, but after the break, general Bay water quality improved. Despite the water quality improvements found in the general Pleasant Bay system, there continues to be water quality problems in the coastal waters of the upper reaches of the Pleasant Bay system, as addressed in findings WR21. In Orleans these reaches include, Areys Pond, Meetinghouse Pond, Pah Wah Pond, Little Cove and Lonny's Pond.

WRF20. The Commission finds that the proposed project as conditioned through the Adaptive Management Plan will account for water quality uncertainty resulting from the Pleasant Bay

breach and is therefore consistent with Regional Policy Plan MPS WR 3.1 critical nitrogen loading standard, MPS 3.2 maintain or improvement of nitrogen loading and MPS 5.1 water quality improvement nitrogen loading standard.

WRF21. Appendix I of the CWMP provides information for four proposed cluster systems targeted to expedite nitrogen removal from the Pleasant Bay tributaries. The four Cluster systems are proposed to have treatment efficiencies of 5 to 8 ppm nitrogen, as shown on Table 2, below, excerpted from the CWMP Table I-3:

TABLE 2 Characteristics of Four Cluster systems in the Pleasant Bay Watershed

Characteristics	Little Cove	Lonnie's Pond	Areys Pond	Paw Wah Pond
Properties to be served	29	31	27	37
Design Flow	14000	14000	9900	21000
Average Flow	5900	5500	3400	9400
Target N PPM	5	5	8	5
N lbs Removed	379	439	187	611
% of TMDL N Removed	na	67	60	67
Within 10 yr Time of Travel	na	90%	100%	60%

The four Cluster collection systems were designed to capture at least 60% of the nitrogen load that needs to be removed according to the local Pleasant Bay sub watershed TMDLs, shown in Table 1. The Cluster systems are proposed to be designed at the end of Phase 1 and built in Phase 2. The combined present design and average day flows for the four cluster systems are 58,900 and 24,200 gpd respectively. The design phase for the Cluster systems will involve a more thorough review of this approach including MEP evaluation of water quality improvement and its cost-effectiveness. The Cluster system approach is a reasonable strategy to expedite nitrogen removal within the headwaters of significantly impaired coastal waters. The cluster plants could be retrofitted as pumping stations for potential future centralized sewer expansions for the greater Pleasant Bay watershed. The effort to obtain the local sites and sewer the nearby areas for expedited deployment of localized treatment would be beneficial to the long term Six Phase Plan, if fully implemented.

WRF22. The Commission Sub Committee requested that the Town expedite the design and implementation of the Cluster Plants for Pleasant Bay. The Town has indicated that they will include the evaluation in the Preliminary Design.

WRF23. The cluster system design evaluation will address expedited nitrogen removal of a substantial quantity (60% of the required amount to be removed) towards meeting the TMDLs, (Table 1). The Commission recommends that water quality improvement should be a priority criterion for comparison, and if found appropriate, the Town is encouraged to consider including cluster systems design and permitting components in Phase 1.

WRF24. A cluster system for Meetinghouse Pond is not proposed because the required TMDL removal is 100% as shown on Table 1 and Figure 1. Meetinghouse Pond Watershed is not scheduled for collection until Phase 2 during the years 2018-2020.

WRF25. A fifth cluster system is proposed to serve the upgradient parcels adjacent to Bakers Pond. The proposed cluster system is a Title 5 system with a leach field located down gradient of the pond to remove wastewater nutrients from the near shore upgradient area. The town has elected to include this action for proactive water quality protection even though the pond report of CWMP Appendix A indicates that significant investment in off-site sanitary management is not warranted for the Bakers Pond watershed.

WRF26. Cedar Pond is a significantly impaired surface water body in Orleans, but conclusions about its condition are deferred to a revised MEP report for Rock Harbor. The MEP report indicates that Cedar Pond is a somewhat brackish water body, and provides the benefit of natural attenuation of nitrogen in its watershed, which is typically associated with a fresh water pond. Since the draft MEP report was issued however, the surface water connection to Rock Harbor has been improved to restore the run of herring. This has changed the nature of Cedar Pond towards being more saline and potentially more sensitive to nitrogen. Less attenuation of watershed nitrogen to the Rock Harbor system would be accomplished by Cedar Pond as a result of the change to a nitrogen limited system. Therefore additional MEP assessment is underway to re-evaluate the amount of septic nitrogen that needs to be removed from the watershed.

WRF27. The CWMP screened 30 sites and evaluated 10 for their potential to accept effluent and by evaluating the potential downgradient water resource impacts. More in-depth analysis was conducted by the Town on site "241," the Tri-Town Septage Facility site and Nauset School playing fields. The Town selected the Tri-Town site as the location for the proposed wastewater treatment facility. The site of the proposed facility is in the Namskaket Creek watershed. The Town Planner provided testimony that there were no private wells within 400 feet of the proposed facility. Commission Water Resources staff reviewed the scope of work for the loading test at the Tri-Town site and observed the test in the field. Commission Water Resources staff also reviewed the scope of work for the groundwater modeling study and commented on the draft and final site assessment documents that are included in the CWMP as part of the S/FEIR Appendices. USGS hydrologists also reviewed the groundwater modeling of the proposed new discharge and found it acceptable. The Commission finds that the project is consistent with MPS WR 3.6 and MPS 5.2 which allows wastewater treatment facilities to be located in a Marine Water Recharge Areas and that the project is consistent with MPS WR1.2 the identification of private wells.

WRF28. The location of the Tri-Town Septage Treatment Facility is off Bay Ridge Lane, near Exit 12 of Route 6. The regional facility treats and discharges approximately 30,000 gallons per day of treated septage effluent, at a nitrogen concentration of approximately 30 ppm into the Monomoy Lens of the Cape Cod Aquifer. The facility is located in the Marine Water Recharge Area to the Namskaket Marsh system.

WRF29. Treated septage effluent from the discharge beds infiltrates into the ground, is assimilated into the water table and the dissolved substances of the treated effluent are carried with groundwater flow in a north to northwest direction towards the Namskaket Creek, Little Namskaket Creek, and Cape Cod Bay.

WRF30. The phenomena of groundwater flow and the plume of dissolved substances has been studied by the USGS since the Tri-Town Plant came on line in February 1990 resulting in a series of papers that were published in the 1990s. In general, the plume of dissolved substances flows to a depth in the aquifer and is impeded by a clay layer that dips to the north restricting

the flow of dissolved substance upward to the marsh. The hydrogeology north of the site has not been totally documented, but based upon the Tri-Town studies, the USGS project chief testified that it is reasonable to expect that less than 50% of the dissolved substances that will be entrained with groundwater flow from the proposed plant will emerge into Namskaket Marsh.

WRF31. Groundwater Modeling conducted by Wright-Pierce, the consultant for the Town of Orleans, indicates that, at design flows, 67% of the treated effluent may discharge into Namskaket Creek drainage area, 8% into Little Namskaket Marsh drainage area and 25% bypassing Namskaket Marsh to Cape Cod Bay. The Groundwater modeling of the Marsh takes a conservative approach with respect to the continuity of the clay layer and the permeability of the Marsh peat deposits that would impede the flow of dissolved substances. Therefore the results of the model present a worst case scenario in which the plume of dissolved substances readily discharges into the Namskaket Creek and the adjacent system to the northeast, the Little Namskaket Creek. Use of the percentages above for evaluating impacts is a conservative approach.

WRF32. Based on the conservative approach discussed above, approximately 67% of the treated effluent is estimated to flow into the Namskaket Marsh system. The Marsh system receives approximately 4.59 Million gallons per day (MGD) is natural groundwater discharge. The WWTF will add approximately 0.48 MGD resulting in a 9 percent increase of relatively fresh water. The salinity as measured in the creek at low tide proximate to Hurleys Bog is 2.4 parts per thousand with an average flow of 1 MGD. The conservative addition of treated flow could decrease the salinity during the low tide period from 2.4 to 1.7ppt. The salinity of the creek ranges from up to 30 ppt at high tide. The increased flow from the wastewater treatment facility will not significantly impact the hydrologic balance or salinity of the Marsh and the Commission finds that the project is consistent with MPS WR 6.3 hydrologic balance.

WRF33. The Namskaket Marsh was first sampled and closed for shellfishing due to bacteria in 1987, three years prior to the Tri-Town plant being on line in February 1990. Bacteria do not survive well in groundwater systems and the proposed wastewater treatment facility will have disinfection. Common sources of bacteria are due to stormwater runoff and local sources. It is unlikely that the Coliform bacteria problem will be exacerbated by the WWTF for the reasons stated above and because the treatment will include disinfection and the Commission finds that the project is consistent with MPS WR 6.3 Hydrologic Balance.

WRF34. The USGS Report Wetland Plants and Algae in a Coastal Marsh, WRI 98-4011, provided a survey of ecological habitat of the Namskaket Marsh and Hurleys bog. Requirements for groundwater monitoring of the WWTF should be expanded to evaluate ecological habitat and make use of the previous USGS study as a baseline.

WRF35. The CWMP presented an extensive site characterization of the Tri-Town Site. The area of infiltration includes 10 beds for a total of 140,000 ft^2. The site specific loading test indicates that at a composite loading rate of 7.7 gpd/ft^2, the average annual discharge of 640,000 gallons per day (gpd) of the Core Sewer Plan can easily be accommodated within the 1.78 million gallons per day (mgd) maximum month infiltration capacity. The CWMP indicates that under a potential expanded plan of sewering the whole Town with a 1.14 mgd average annual flow (2.0 mgd maximum month), additional effluent disposal sites or water reuse options will be required. The detailed groundwater modeling analysis concluded that at a maximum month flow of 2.07 mgd (which is more than the aggregation of the Orleans' Core Plan, and the Eastham and Brewster contributions), the groundwater mounding, although appreciable, would still be greater than 20 feet below the ground surface and that the evaluation has shown no

likelihood of breakout, or flooding of nearby basements or septic systems. The modeling also indicates that an average flow of 0.740 mgd from the site would not contribute effluent nitrogen load to the adjacent Rock Harbor or Nauset Marsh watersheds.

WRF36. The Commission finds that the wastewater treatment facility design will be conditioned (WRC13) to provide a turf and landscape management plan and stormwater quality treatment and management plans for consistency with MPS WR1.5 for turf and landscape plans and MPS WR7.1 to 7.10 for stormwater management provisions.

WRF37. The Namskaket Creek Estuarine system lies within the boundaries of both the Town of Orleans and the Town of Brewster. Because the nitrogen assimilative capacity of this system is in excess of the current loadings, both towns have a shared interest in the protection and management of this assimilative capacity, and other natural and water resources of this system.

WRF38. According to the MEP Technical Report and Technical Memo, dated April 1, 2011, 35% of assimilative capacity of the Namskaket Creek watershed is presently taken up by development, of which 20 % is Brewster and 8% is Orleans and 7 % is Tri-Town septage plant. The proposed Wastewater Treatment Facility will use a net additional 4% of the capacity, leaving 61% of the assimilative capacity. Build-out in the watershed, assumed at 26% growth, is estimated to use an additional 7% of the assimilative capacity.

WRF39. The Commission finds that there is assimilative capacity in the Namskaket Marsh system to accommodate nitrogen from the project for consistency with MPS WR 3.1 critical nitrogen load, MPS 3.2 maintain or improvement of nitrogen loading and MPS 5.1 water quality improvement nitrogen loading standard.

WRF40. The CWMP evaluation of the transfer of wastewater flows from collection systems to the Tri-Town site demonstrates that the redistribution of water within the Town due to sewering is unlikely to produce hydrological balance impacts and the Commission finds the that the project is consistent with MPS WR 6.3 hydrologic balance.

WRF41. The recommended wastewater treatment design is a conventional Bardenpho design as described in Appendix D of the S/FEIR. This process design is capable of achieving Level 2 treatment levels that can achieve nitrogen effluent concentrations of 3 to 5 parts per million (ppm) and includes a provision for sludge and septage handling. The Commission finds that the project is consistent with MPS WR 6.8. The treatment facility design for the phased and expanded Town-wide system is also included in S/FEIR Appendix D.

WRF42. Wright-Pierce indicated that the proposed wastewater treatment system will attain an effluent nitrogen concentration of less than 5 ppm and the Commission finds that the project is consistent with MPS WR 2.1 for achieving less than 5 ppm effluent and MPS WR 6.2 for tertiary treatment.

WRF43. The Town has voted at the 2011 Annual Town Meeting to conduct an analysis of alternative collection systems.

WRF44. Barnstable County has appropriated funds to conduct a review of the MEP science and its use as the basis of attaining water quality goals and TMDLs of the Clean Water Act.

WRF45. The record includes testimony that there are options for modifying the state's water quality goal for Rock Harbor which may impact the area of required sewering in that watershed.

WRF46. Orleans shares its surrounding coastal waters of Pleasant Bay with the neighboring towns of Brewster, Harwich, and Chatham, and shares Nauset Marsh/Town Cove and Rock Harbor with Eastham. Alternative Plans 1, 2 and 3 considered in the CWMP involve attaining net reductions of nitrogen to meet Orleans' share of nitrogen removal. The Town of Orleans has chosen to proceed with the preferred alternative that is based on Plan 2, which provides the fundamental wastewater infrastructure building block which will lead the town towards meeting its TMDL obligations and accommodate potential changes through adaptive management.

WRF47. The Commission supports a watershed based approach to wastewater planning to promote and hasten TMDL compliance. This means that towns in shared watersheds need to work together to establish how to apportion responsibility for nitrogen removal among those communities. Planning and construction of shared, regional wastewater collection, treatment and/or disposal facilities to meet TMDLs will reduce costs region-wide and will promote, and potentially hasten, TMDL compliance in shared watersheds. The Commission acknowledges the challenge of promoting regional facilities when the fifteen towns of Cape Cod are at different stages of wastewater planning, are facing different financial constraints, and may have different engineering consultants with divergent views on infrastructure options. In addition, many towns are awaiting reports from the Massachusetts Estuaries Project about TMDLs. However, one of the purposes of the Cape Cod Commission is to further the provision of adequate capital facilities. The Commission would like to see towns which contribute to nitrogen loading in a particular watershed to enter into Memorandums of Agreement with other contributing towns so that TMDLs are addressed watershed by watershed Cape-wide. In addition, the Commission would like to see a robust analysis of options, including potential economic benefits, for sharing infrastructure to address pollutant removal requirements in impaired waterbodies.

WRF48. The proposed area of sewering in the Orleans CWMP will only meet the Orleans share of the TMDL requirements of the shared embayments. Attainment of the TMDLs for the shared embayments will require that Chatham, Harwich, Brewster and Eastham also provide nitrogen removal. The Orleans CWMP provides options for the future participation of Brewster and Eastham by identifying the potential shared use of the proposed wastewater treatment facility as a preference to more extensive sewering in the Town of Orleans. The assessment indicated that regional solutions offer 6% to9% capital cost savings and 18% to 25% O & M cost savings. For these reasons the Commission finds that the project accommodates and allows for regional solutions and is consistent with MPS WR 3.1 critical nitrogen load, MPS 3.2 maintain or improvement of nitrogen loading and MPS 5.1 water quality improvement nitrogen loading standard.

WRF49. Orleans completed a regional wastewater management study that evaluated regional solutions to achieving shared wastewater needs that was funded by Barnstable County through the Cape Cod Water Protection Collaborative entitled, Wastewater Regionalization Study: Orleans-Brewster-Eastham, December 2009. The findings of this study clearly indicate there are significant cost savings for a regional wastewater management approach between the Towns and that the benefit of sharing a suitable facility site is considerable. The study also presents a number of mechanisms for management and cost sharing.

WRF50. Shared management of wastewater infrastructure among Orleans, Eastham and Brewster has been ongoing through their participation in the Groundwater Protection District with its septage treatment plant at the Tri-Town site in Orleans.

WRF51. There are significant constraints to identifying suitable sites for wastewater facilities in Eastham. Eastham has indicated its general support for the Orleans CWMP and that wastewater collection in the Eastham side of the Nauset watershed for treatment at a regional shared wastewater facility would be a reasonable alternative to achieving the required nitrogen reduction for the Nauset Marsh system.

WRF52. The Town of Brewster has indicated its general support for the Orleans CWMP and stated that the Town "looks forward to an ongoing, collaborative relationship as we plan for the protection and preservation of our shared resources."

WRF53. The Brewster Conservation Commission has requested to be copied on monitoring tests and other materials related to monitoring conditions for the proposed wastewater treatment facility.

WRF54. Ensuring that regional management of wastewater strategies will be implemented will require that a Memorandum of Agreement or some other legal agreement be developed between Orleans and Brewster and/or between Orleans and Eastham.

WRF55. Any regional wastewater management solutions will be informed by new information and potential future opportunities, such as release of the MEP Nauset Report, confirmatory modeling and town directives. Some of these items will occur as part of the Preliminary Design, but other actions will occur during the 20-year course of phased implementation. For regional solutions to remain viable, treatment capacity to accommodate them must be reserved at the proposed WWTF until a decision can be reasonably made. The first construction phase of the WWTF will be for 320,000 gpd (2015). The second construction phase for the facility is projected to begin in 2024 at the beginning of Phase 4 to expand capacity to 640,000 gpd.

WRF56. The Tri-Town site serves as a regional resource for septage disposal and the preference of the Commission is that it continues to serve as a regional wastewater facility asset.

WRF57. If the Town proposes to proceed with expanding the sewer service area to a majority of the Town (something which is not part of the plan proposed in the CWMP) while at the same time reserving capacity for regional solutions, then the Tri-town site will not be able to accommodate the combined future flows for infiltration and additional effluent disposal sites or expanded capacity will be required.

WRF58. The Commission finds that public drinking water laboratory results and Annual Statistical Reports, as they are filed with the DEP, provide valuable information for understanding the state of natural resources and drinking water supplies across the Cape, and supports the Commission's understanding of the adequacy of capital facilities in the region.

WRF59. The CWMP proposes a system of adaptive management to gauge the overall success of meeting the water quality goals with flexibility to adjust each phase of the project based on new information that may be generated over the course of its implementation.

WRF60. The scope of an Adaptive Management Plan, Exhibit A of this decision, with monitoring conditions has been reviewed and agreed upon by the Town and Cape Cod Commission.

WRF61. The Commission finds that, based upon the materials submitted for the record and the conditions of this decision, the proposed project and its Adaptive Management Plan allow for

changes in the course of its implementation, including alternative technology. The Plan also accommodates and allows for regional solutions, which is consistent with the Regional Policy Plan Minimum Performance Standards.

Wildlife and Plant Habitat Findings

WPHF1. Based on the information in the record, the Commission finds the Tri-Town Septage facility site is mapped as a Sensitive Natural Resource Area on the Regional Policy Plan Open Space Map due to the presence of priority habitat for Eastern Box Turtle, a state-listed species of special concern. The site contains and abuts wetland resource areas.

WPHF2. Based on the April 14, 2009 LEC Environmental Consultants' Natural Resources Assessment, located in Appendix H in the CWMP, submitted to the Natural Heritage and Endangered Species Program (NHESP) during the MEPA review process, the Commission finds that the proposed project has adequately addressed the requirements of MPS WPH1.1, Natural Resources Inventory for the Tri-Town site.

WPHF3. Based on the information submitted for the record, the Commission finds the proposed treatment facility site at the Tri-Town plant location maximizes reuse of existing facilities and disturbed areas, minimizes additional fragmentation of the site, and avoids impacts to wetlands. In addition, the Town proposes to utilize existing disturbed rights-of-way for the majority of the sewer main installation, and avoid "over-land" routes. By utilizing previously disturbed areas the Commission finds the project minimizes impacts to undisturbed areas, consistent with MPS WPH1.2 and MPS WPH1.3.

WPHF4. Based on the information presented in the record, the Commission finds that potential future expansion of the treatment facility would require additional effluent disposal capacity, which might be accommodated on this site or other Town-owned sites. The S/FEIR states that the Town will seek additional regulatory review if or when expansion of the plant is contemplated.

WPHF5. Based on the information presented in the record, as of the date of this DRI decision, the NHESP had not yet made a determination as to whether the project will result in a "take" of Eastern Box turtle, or whether the project may be conditioned to avoid a take under the state MESA. If the project is determined to result in a take, the Town will be required to file with the NHESP for a Conservation and Management Permit which will detail mitigation measures required to address impacts to box turtles. Mitigation measures may include restoration of habitat, preservation of open space, or other measures. The Commission finds that the project may be conditioned to ensure compliance with the state MESA requirements, consistent with the requirements of MPS WPH1.4.

WPHF5. According to the LEC Natural Resources Assessment, the Tri-Town treatment plant site does not contain vernal pools, and thus the Commission finds that MPS WPH1.5 does not apply.

Wetlands Findings

WETF1. Based on the information presented in the record, the Commission finds the project may be conditioned to ensure that invasive species are managed during construction on the treatment plant site, consistent with MPS WPH1.6.

WETF2. Based on the information presented in the record, the Commission finds that installation of the wastewater treatment facility will not result in impacts to wetlands or their buffers, consistent with MPS WET1.1 and MPS WET1.2.

WETF3. Information submitted to date indicates that the sewer main installation will avoid impacts to most wetland resources. The RPP allows for wetland disturbance for utility installations where there are no other feasible alternatives. In these instances mitigation may be required. The Town has offered wetland restoration at offsite locations as possible mitigation for unavoidable wetland disturbance, which the Commission finds is consistent with MPS WET1.3.

Open Space Findings

OSF1. MPS OS1.3 exempts municipal projects for municipal purposes from provision of open space. Therefore, the Town is not required to provide open space for development associated with the CWMP.

Coastal Resources Findings

CRF1. The Coastal Resources section of the Regional Policy Plan minimizes potential impacts from development on coastal hazard mitigation and coastal water quality and habitat, the coastal section also encourages maritime industry, character and public access. The areas of coastal hazard mitigation include, development in a V-Zone (CR2.1), accommodating sea level rise(CR2.2), allowing for migration of coastal resources (CR2.3), damage prevention and flood minimization(CR2.4), protection of coastal beaches, coastal dunes and their buffers(CR2.5 and CR3.1), coastal banks (CR2.6), disaster reconstruction (CR2.7) and stormwater management(CR3.3 and CR3.4). The CWMP addresses these issues indicating they will be implemented through the local Conservation Commission and incorporated into the facility plan design. As such the Commission finds that the CWMP can be conditioned to be consistent with these appropriate minimum performance standards as per WRC13.

CRF2. In accordance with MPS CR3.10 (Eelgrass), development shall have no direct or indirect adverse impacts to eelgrass beds, unless there is no feasible alternative location or design for the project or the project accomplishes an overriding public benefit. Based on the materials submitted for the record, the Commission finds that effluent from the proposed Orleans wastewater treatment facility will enter the soil within open infiltration basins and mix with groundwater that eventually discharges toward Cape Cod Bay. Eelgrass beds located seaward of Namskaket Creek, Little Namskaket Creek, and Rock Harbor could potentially be affected by effluent discharged from the proposed Orleans wastewater treatment facility. Based on the information presented in the record, the Commission finds that it is appropriate to condition the project to monitor the potential impacts of effluent discharge to intertidal and sub-tidal habitats, including eelgrass beds, to detect and avoid any direct or indirect adverse impacts to this sensitive and critical resource consistent with the Adaptive Management Plan Scope of Exhibit A. The Commission further finds that the project provides an overriding public benefit of the reduction of nitrogen in sensitive embayments.

CRF3. MPS CR3.11 (Fish, Shellfish, Crustaceans) requires that any structures or construction activities associated with implementation of the CWMP shall be designed and constructed to minimize direct and indirect impacts to fish, shellfish, crustaceans and their habitat. As stated in CRF2, the Commission finds that effluent from the proposed Orleans wastewater treatment facility will flow via groundwater and discharge into Namskaket Marsh and Cape Cod Bay. Based on the information presented in the record, the Commission finds that it is appropriate to condition the project to monitor the potential impacts of effluent discharge to the intertidal and

subtidal habitats of the bay seaward of the treatment facility consistent with the Adaptive Management Plan scope, Exhibit A.

Heritage Preservation/Archeological Resources/Community Character Findings
HPCCF1. The Massachusetts Historical Commission (MHC) reviewed the proposed new facilities for treatment and disposal at the Tri-town site and determined that significant archaeological resources are unlikely to exist in the project area. In a letter dated December 20, 2010, MHC concurs that the preferred alternative layout for the Tri-town site will occur within areas previously disturbed by original facility construction and is unlikely to contain significant archaeological resources. Based on this testimony submitted for the record, the Commission finds the proposed development at the Tri-Town site is unlikely to result in disturbance of significant archeological resources, and as such, is consistent with MPS HPCC1.3 (Archeological Sites).

HPCCF2. The Commission finds that based on the information submitted in the record, including the Single/Final EIR/CWMP, the Applicant has agreed to conduct an archaeological survey during the preliminary design phase of the project at any proposed cluster treatment sites where there is archaeological sensitivity, consistent with RPP MPS HPCC 1.3 (Archaeological Sites). Conducting such survey work will require a permit from the State Archaeologist/MHC. As such, the Commission finds the proposed project can be conditioned to be consistent with MPS HPCC1.3.

HPCCF3. The Commission finds that based on the information submitted in the record, including the Single/Final EIR/CWMP that the Applicant has proposed that any above-ground structures within the Old Kings Highway Historic District will be designed with architectural features consistent with the district standards. MHC has requested that the project proponent submit existing and proposed conditions plans to MHC for review as each phase of the project is developed. Review of any proposed structures by MHC and the Old Kings Highway Historic District Committee in Orleans will address issues raised in MPS HPCC 1.1 (Historic Structures) and MPS HPCC 2.4 (Consistency with Regional Context or Surrounding Distinctive Area).

Transportation Findings
TRF1. Based on a March 8, 2011 Memo from Heather Merriman and Michael Giggey of Wright-Pierce to George Meservey (part of a 3/11/11 letter), the Commission finds that current peak hour traffic for the Tri-Town plant does not exceed 25 peak hour trips, and that the expected trips at the proposed wastewater facility are anticipated to be lower.

TRF2. The Commission finds that a review of crash records is unnecessary relative to MPS TR1.2 (Crash Frequency at Key Locations) and identification of safety improvements per MPS TR1.3 (Identification of Safety Impacts) is unnecessary because the new facility is expected to generate less than 25 peak hour trips of all vehicle types. Based on this, the Commission finds the proposed project is consistent with MPS TR1.2 and TR1.3.

TRF3. Based on a 4/7/11 Memo from Commission staff, the Tri-Town facility's main driveway at Overland Way, Orleans, meets the stricter of the Massachusetts Department of Transportation and American Association of State Highway Transportation Officials guidelines for safe stopping sight distances, as required by MPS TR1.8 (Sight Distance Requirements). The Commission finds the stopping sight distances at Overland Way as measured by Commission staff to be as shown in the table on the next page, below:

Speed (mph)	Recommended SSD	Southbound Existing SSD	Northbound Existing SSD
20	115	400'+	140'

Source: A Policy on Geometric Design of Highways and Streets, AASHTO 2004

TRF4. Concerns relative to post construction roadway conditions for both public and private roadways were raised during the public hearings and meetings. This includes a concern raised by Commission Member Ernest Virgilio at the 3/23/11 Subcommittee meeting. The Town of Orleans, through Mr. Meservey, Director of Planning & Community Development provided a March 15, 2011 Email stating *"it is expected that the vast majority of the sewage collection system will be installed within street rights of way. Final design may indicate that it is necessary to acquire an easement for a so called cross-country installation in one or more locations. Should that prove to be the case, the law authorizes a Town to obtain easements rights by purchase or eminent domain."* The Town also provided a March 29, 2011 letter from Mr. Meservey that states *"when water mains are installed or replaced that require excavation on a private road, the street surface is restored to a condition equal to or better than the pre-existing condition. When sewers are installed on private roads, it is the intention of the Town to follow a similar pattern and restore the roads to an equal or better condition."* Based on this testimony, the Commission finds that it is appropriate to condition the project to require that that Town of Orleans repair roads affected by project construction impacts.

CONCLUSION

Based on the Findings above, the Commission hereby concludes:

1. The proposed project is consistent with Orleans local development by-laws.

2. The proposed project is consistent with Orleans Local Comprehensive Plan.

3. The proposed project does not fall within a District of Critical Planning Concern.

4. The proposed project falls within the Pleasant Bay and Cape Cod Bay Areas of Critical Environmental Concern (ACEC), but complies with State laws governing these areas.

5. The proposed project is consistent with all the Minimum Performance Standards of the 2009 Regional Policy Plan (as amended).

6. The probable benefits of the proposed project outweigh the probable detriments resulting from the development.

The Commission hereby approves with conditions the application of the Town of Orleans CWMP project as a DRI, provided the following conditions are met:

General Conditions

GC1. This DRI decision is valid for 7 years. The Town of Orleans may seek an extension of this DRI permit prior to the expiration of this DRI in accordance with the Commission's *Enabling Regulations.*

GC2. Failure to comply with all conditions stated herein, and with all related statutes and other regulatory measures, shall be deemed cause to revoke or modify this decision.

GC3. The Applicant shall obtain all necessary federal, state, and local permits for the proposed project.

GC4. No development work, as the term "development" is defined in the Cape Cod Commission Act, shall be undertaken until all appeal periods have elapsed or, if such an appeal has been filed, until all judicial proceedings have been completed.

GC5. The proposed project shall be constructed and implemented in accordance with the Final Comprehensive Wastewater Management Plan/Final Environmental Impact Report, December 2010, prepared by Wright-Pierce, consistent with the findings and conditions of this decision and contingent upon Town Meeting funding. Changes to the CWMP that would affect TMDL compliance or otherwise change or impact the findings and/or conditions of this decision, shall be reviewed and evaluated through a modification to the DRI decision pursuant to the Commission's *Enabling Regulations* in effect at the time of the request. The Applicant shall submit to the Commission any additional information deemed necessary to evaluate any modifications to the approved plan.

GC6. On or before April 13, 2018, the Applicant may return to the Commission to seek an extension of this decision by the Regulatory Committee of the Commission. If said extension is approved, said extension may allow the Applicant to return to the Commission one year prior to the expiration of the extension decision to seek either a renewal or further extension of the DRI approval as the Commission's *Enabling Regulations* in effect at the time of the request may allow.

GC7. Prior to issuance of a Preliminary Certificate of Compliance for any proposed construction recommended in the CWMP (also referred to as the "project" or as "development" as defined by the Cape Cod Commission Act) and as approved herein, the Applicant shall submit the preliminary design report for review by Commission staff to determine its consistency with this decision. If Commission staff determines that the preliminary design report is not consistent with the CWMP approved as part of this decision, the Commission shall require that the Applicant seek a modification to this decision in accordance with the Modification section of the Commission's *Enabling Regulations* in effect at the time the modification is sought.

GC8. The Applicant may seek a modification of this decision in accordance with the Modification section of the Commission's *Enabling Regulations* in effect at the time the modification is sought.

GC9. Prior to the commencement of the first phase of project construction, and prior to the issuance of any Building Permit for development, the Applicant shall obtain a Preliminary Certificate of Compliance from the Commission that states that all conditions in this decision that are required to be addressed prior to commencement of construction and/or pertaining to issuance of a Building Permit have been met, including providing written proof to the Commission that a copy of this decision has been provided to the general contractor(s) at least thirty (30) calendar days prior to commencement of construction.

GC10. Prior to the commencement of treatment facility operations, the Applicant shall obtain a Final Certificate of Compliance from the Commission that finds and states that all conditions pertaining to issuance of a Final Certificate of Compliance have been met.

GC11. The Applicant shall notify Commission staff in writing at least thirty (30) calendar days prior to its intent to seek a Preliminary and Final Certificate of Compliance. Such notification

shall include a list of key contact(s), along with their telephone numbers, mailing addresses, and email addresses, for questions that may arise during the Commission's compliance review. Commission staff shall complete an inspection under this condition, if needed, and inform the Applicant in writing of any deficiencies and corrections needed.

GC12. The Applicant shall construct and implement the project in accordance with the Adaptive Management Plan. A preliminary scope of the Adaptive Management Plan *(Exhibit A)* is attached to and incorporated into this decision by reference.

GC13. The Applicant agrees to allow Commission staff to enter onto the Tri-Town plant site or other Town property which is the subject of this decision, after reasonable notice to the Applicant, for the purpose of determining whether the conditions contained in this decision, including those linked to each Preliminary and Final Certificate of Compliance have been met.

GC14. The proposed facilities described in the Orleans CWMP may be constructed in Phases.

Water Resources Conditions

WRC1. In the Preliminary Design the Town shall incorporate the Nauset Marsh MEP Technical Threshold and TMDL into the recommended CWMP design and revise the amount of proposed sewering as appropriate, indicating targets. If the TMDL targets change from the placeholder value in the CWMP the Town shall submit design revisions to the Commission staff for review and approval.

WRC2. In the Preliminary Design, the Town shall incorporate the revised Rock Harbor MEP Technical Threshold and TMDL into the recommended CWMP design and revise the area of proposed sewering as appropriate, indicating targets. If the percent removal changes from the MEP threshold value the Town shall submit design revisions to the Commission staff for review and approval.

WRC3. Confirmatory modeling involves use of the MEP models for each estuary under various proposed sewering scenarios. This information will provide projections of anticipated reductions of nitrogen in the water column of impacted estuaries from each proposed phase of sewering, including the cluster system alternative. Another set of scenarios will evaluate and confirm the assimilative capacity of Namskaket Marsh and sentinel water quality thresholds. The Town shall develop a scope of MEP modeling scenarios for each embayment, either together or successively, for Commission staff review and approval.

WRC4. The Town shall incorporate the findings of the future MEP scenario evaluations as described in WRC3 into:

- The location and timing of sewer expansion areas to expedite nitrogen removal in the TMDL watersheds;
- Technical support for the Wastewater effluent disposal Ground Water Discharge Permit at the Tri-Town Site; and
- Reviewing the anticipated water quality improvements of the head waters of Pleasant Bay embayments due to Cluster systems and incorporating the evaluation into the design of the location, nature and extent of the local service areas to expedite nutrient removal.

WRC5. As laid out in the Orleans CWMP, provisions for regionalization remain open until the design for Phase 4 of the Plan. The Commission shall coordinate regional meetings for bringing the towns together to further discussions regarding regional wastewater solutions. The Town of

Orleans shall attend and participate in Commission hosted workshops in which the Commission will facilitate discussions among the towns of Orleans, Brewster and Eastham regarding achieving TMDL compliance in shared watersheds. The Commission shall provide technical assistance to address options for attaining compliance with nitrogen TMDLs for shared watersheds, including the sharing of capital infrastructure, operations and maintenance costs. As part of these workshops, the Commission shall further facilitate discussions on the topic of sharing the Orleans Wastewater facility by the Towns of Eastham and Brewster. The Town shall incorporate results of those discussions that are agreed upon by the Towns of Orleans, Brewster and Eastham and by the Commission into the design plans and include those results as part of its Adaptive Management Plan reporting.

WRC6. The Town shall report every 2 years on the status of regionalization discussions and agreements among the Towns of Orleans, Brewster and Eastham as part of its regular Adaptive Management Plan report. The status reports on this issue, shall document regionalization activities over the prior two years, identify such activities planned for the upcoming two years, identify issues that have arisen as impediments to effective regionalization, and identify actions that could be taken to overcome those impediments. Reporting on regional status shall continue until either 1) inter-municipal agreements are in effect among the Towns of Orleans, Eastham and Brewster, or 2) the Towns of Brewster and Eastham both notify the Town of Orleans in writing that they no longer wish to pursue regional wastewater management options.

WRC7. The Town shall incorporate discussions and decision-making related to regionalization with Brewster and Eastham in the preliminary design of all proposed wastewater facilities, in the final design of wastewater treatment and effluent disposal facilities in Phases 1 and 4 of the proposed project, and in the final design of any component of the wastewater collection system that facilitates connection of sewers in Eastham and Brewster.

WRC8. The Town shall keep opportunities open for the sharing of the proposed wastewater facilities, including disposal capacity at the Tri-Town site, with Brewster or Eastham prior to seeking an extension to this decision seven years from its effective date, as such extension is required by condition GC1. During the seven years following this decision, the Commission will seek written information from Brewster and Eastham necessary for Orleans to incorporate those town's wastewater flows in the Orleans project design in a reasonable time frame.

WRC9. Should Orleans propose any action that would reduce the remaining available assimilative capacity to less than 50% of the total assimilative capacity in the Namskaket Marsh System, then that proposed action shall be documented in writing by Orleans in the regular Adaptive Management Plan report, or earlier, for review and a determination of consistency with this Decision by Commission staff.

WRC10. The project schedule for the first Phase will be adjusted as issues become resolved through the Preliminary Design task list. Project schedule updates shall be submitted to the Commission as part of the regular Adaptive Management Plan reporting.

WRC11. The extent and prioritization of sewering is shown as the 6 phases of the core plan of the CWMP. The geographic extent may be subject to change due to the Cluster systems to expedite nutrient removal in the upper Pleasant Bay headwaters, need to expand or condense areas serviced based on updated MEP information and confirmatory modeling and regional infrastructure sharing. The Town shall establish criteria that will be used to prioritize sewer expansions as part of the Preliminary Design. As stated in Finding WR24, CCC encourages prioritization for expedited TMDL compliance. Proposed changes to the geographical extent of

the sewer area shall be reported in the regular Adaptive Management Plan report for review and determination of consistency with this Decision by Cape Cod Commission staff.

WRC12. The Non-Structural components of the CWMP include: fertilizer control, storm water management, land use controls, natural attenuation, flushing enhancements and piloting urine diversion and composting toilets. Reporting of progress on these items will be part of the regular Adaptive Management Plan reporting.

WRC13. The Town shall provide final building, site and landscaping plans for the Wastewater Treatment Facility, consistent with finding WRF36, CRF1 and WETF1 detailing, coastal wetland resources, stormwater management, wetland buffers and turf management plan for Commission staff review for a determination of consistency with this Decision.

Adaptive Management Background
The CWMP contains an Adaptive Management Plan (AMP) and steps to assure TMDL compliance through monitoring and reporting. The AMP fits the Phased Sewer Approach very well. The AMP will allow a systematic and prescribed process to report on the town's activities and to incorporate new technical information and potential agreements among the towns in the shared watersheds. This information will aid the local and regional decision making process for the plan's later phases. The AMP will be informed by regular monitoring of water quality in the embayments and reductions of nitrogen load in the watersheds to evaluate TMDL compliance.

WRC14. The Town shall submit for Commission staff review and approval an Adaptive Management Plan that incorporates the scoping items for monitoring, evaluation and reporting as described in Exhibit A, attached to this decision and incorporated by reference, according to the timetable below. The AMP shall detail the resources necessary to implement the aspects of the Plan. The plan will be reviewed with Commission staff according to the following schedule:

- Initial meeting 6 months after securing funds for the Preliminary Design;
- Submit initial draft AMP one year after securing funds for the Preliminary Design;
- Submit Final Adaptive Management Plan for approval by Commission staff two years from securing funds for the Preliminary Design;
- Regular Adaptive Management Plan reports shall be submitted every two years after the beginning of Phase 1 construction, presently scheduled for 2015.

WRC15. Within 6 months of securing funds for the Preliminary Design, the Town shall convene a Technical Review Committee comprised of the Town, DEP and Commission staff, as described below in the Adaptive Management Plan scope of Exhibit A of this decision. The Town shall include a Town of Brewster representative on the Technical Review Committee as an ex-officio non-voting member, as described below in the Adaptive Management Plan scope, Groundwater Discharge Permit, in Exhibit A of this Decision.

WRC16. The Town of Orleans shall consult with the Town of Brewster as part of the Namskaket Creek Monitoring requirements for the Adaptive Management Plan and Ground Water Discharge Permit and provide draft and final GWDP applications to the Town of Brewster.

WRC17. Implementation Progress Reports described in the Adaptive Management Plan scope (Exhibit A of this decision) shall be part of the regular Adaptive Management Plan report that is submitted to Commission staff for review and comment.

WRC18. Project Evaluation Forms, which are submitted to DEP as part of the State Revolving Loan Application, once implementation begins, shall be copied to the Commission.

WRC19. Marine and Surface Water Monitoring Reports of the Adaptive Management Plan Scope, Exhibit A of this decision shall be filed with the Commission every 2 years after the completion of Phase 1. The Technical Review Committee comprised of Cape Cod Commission staff, DEP and the Town shall review the monitoring reports not less than every 5 years, from the commencement of the monitoring program for modifications or changes.

WRC20. Upon approval of the Development of Regional Impact, the Town of Orleans shall submit copies of Ground Water Discharge Permit monitoring reports for the Tri-Town facility to the Commission. Once the proposed wastewater treatment facility is completed, GWDP monitoring and compliance reports for the new facility shall be submitted to the Commission, as identified the Adaptive Management Plan scope attached to this decision as Exhibit A, These reports will be submitted to the Commission at the same time they are submitted to DEP.

WRC21. Consistent with WRF57, upon approval of the Development of Regional Impact, the Town of Orleans shall submit copies to the Cape Cod Commission of public drinking water laboratory results and Annual Statistical Reports, as they are filed with the DEP.

WRC22. The Town will continue to regularly evaluate the health of the ponds and progress in its in-pond and watershed protection efforts according to the recommendations in the CWMP. The Town shall report on improvements in fresh surface-water quality or new efforts as it may relate to the CWMP implementation under the Non-Structural Management actions in its regular Adaptive Management Plan report submitted to the Commission as indicated in the Adaptive Management Plan Scope, Exhibit A of this decision.

WRC23. The Town will continue to regularly evaluate, manage and improve stormwater collection and treatment, as indicated in the CWMP. The Town shall report on improvements of stormwater management and progress as it relates to the CWMP and Stormwater Phase II regulations under Non-Structural Management actions in its regular Adaptive Management Plan report submitted to the Commission as indicated in the Adaptive Management Plan Scope, Exhibit A of this decision.

WRC24. The town will continue to assess opportunities for Enhanced Natural Attenuation or tidal flushing to reduce watershed nitrogen loads as indicated in the CWMP. The Town shall regularly report on improvement of water quality and progress as it relates to the CWMP under Non-Structural Management actions in its regular Adaptive Management Plan report submitted to the Commission as indicated in the Adaptive Management Plan Scope, Exhibit A of this decision.

WRC25. Prior to implementation of Enhanced Natural Attenuation or tidal flushing which alters the implementation of the CWMP, the Town shall obtain a determination of consistency with this Decision from Commission staff to ensure compliance with TMDLs.

WRC26. The studies conducted in support of the groundwater discharge permit during the Preliminary Design shall include a scope for further characterizations of: 1) the subsurface conditions of Namskaket Marsh to address hydrogeologic uncertainty of the clay lens and 2) discrete freshwater breakout in the Namskaket Marsh proximal to the wastewater treatment facility. The hydrogeologic scope shall be submitted to Commission staff for review and approval.

WRC27. The draft Groundwater Discharge Permit application shall be submitted to the Commission for review and comment.

WRC28. The Town shall submit a request to the Commission for modification of this DRI Decision in accordance with its enabling regulations governing Developments of Regional Impact ("Enabling Regulations") if the result of the Analysis of Alternative Collection Systems results in the Town proposing significant changes to the project design.

WRC29. The Town shall submit a request to the Commission for modification to this DRI Decision in accordance with its Enabling Regulations if the results of the Barnstable County evaluation of the MEP science results in a Town proposal of significant changes to the project design.

WRC30. The Town shall submit a request to the Commission for modification to this DRI Decision in accordance with its Enabling Regulations if the state's water quality goals for Rock Harbor Creek are modified by DEP resulting in a Town proposal of significant changes to the project design.

WRC31. The Town of Orleans shall continue to participate in regional studies to evaluate the progress of improved water quality in Pleasant Bay resulting from the phased planned sewering in the collective Pleasant Bay watershed. These studies would be used to inform decisions about the plan's phased implementation consistent with the Adaptive Management Plan

Wildlife and Plant Habitat Conditions

WPHC1. The Town shall continue to work with the Natural Heritage and Endangered Species program (NHESP) to design the project at the treatment plant site to avoid a "take" of state listed rare species. The site design shall incorporate existing disturbed areas on the Tri-Town site to the greatest extent feasible. If the NHESP determines that the project will result in a take of state listed species and requires preparation of a conservation and management permit, the Town shall submit the project plans and proposed mitigation plan to NHESP, with a copy to the Commission.

WPHC2. The Town shall utilize existing disturbed areas within road rights-of-way and utility easements to the greatest extent feasible for the sewer line installation. Where sewer lines are proposed within mapped rare species habitat, the town shall submit the proposal to the NHESP. If the NHESP determines that the project will result in a take of state listed species and requires preparation of a conservation and management permit, the Town shall submit the project plans and proposed mitigation plan to NHESP, with a copy to the Commission.

WPHC3. The Town shall seek additional Commission regulatory review if or when the Town seeks to expand the treatment plant, add additional effluent disposal beds, or make additional changes to the treatment plant site plan beyond that depicted as the Core Plan in the CWMP.

WPHC4. The Town shall submit a plan for managing the introduction of invasive species to construction sites consistent with Technical Bulletin 01-001 prior to construction of the treatment plant or sewer mains.

Wetlands Conditions

WETC1. The Town shall construct the treatment plant to avoid any physical alteration to wetlands or the 100 foot buffer to wetlands. Physical alteration of previously disturbed wetland buffer areas may be allowed where there is no feasible alternative and where the disturbance

will not result in greater physical alteration to the buffer area (e.g. a pervious area becomes impervious).

WETC2. The Town shall install the sewer lines and pumping facilities to avoid impacts to wetlands and the 100 foot buffer to wetlands. Physical alteration of wetlands and buffers may occur for utility line installation where there is no feasible alternative, the alteration is the minimum amount necessary, and the site is restored following construction. The Town shall provide restoration of wetlands elsewhere in Orleans as mitigation for unavoidable impacts to wetlands. The construction protocol and the proposed mitigation shall be provided to the Commission.

Coastal Resources Conditions

CRC1. To ensure compliance with MPS CR3.10 (Eelgrass) and CR3.11 (Fish, Shellfish, Crustaceans), the Town in concert with the Technical Review Committee of the Adaptive Management Plan shall prepare a biological monitoring plan. The monitoring plan should be designed to evaluate short- and long-term changes, if any, in water quality parameters, species and community composition, structure and distribution, etc. in intertidal and sub-tidal environments (e.g., salt marsh, intertidal flat, eelgrass and other sub-tidal benthic habitats, etc.) in the Namskaket/Little Namskaket Creek and Rock Harbor area. The monitoring plan shall include a monitoring and reporting schedule (approved by the Commission) that is designed to capture short- and long-term changes in coastal and marine conditions and ecosystems adjacent to the treatment facility. The results of environmental monitoring shall inform and be incorporated into the Adaptive Management Component of the CWMP. The biological monitoring plan shall be submitted prior to issuance by the Commission of a Preliminary Certificate of Compliance, and prior to commencement of construction.

CRC2. The project involves development within the Pleasant Bay and Cape Cod Bay ACEC. No new development shall be permitted on barrier beaches or coastal dunes within these ACECs to ensure compliance with CR2.5 of the RPP.

Heritage Preservation/Archeological Resources/Community Character Conditions

HPCC/C1. The Applicant shall conduct an archaeological survey during the preliminary design phase of the project, with a permit from the office of the State Archaeologist/Massachusetts Historical Commission (MHC), at any proposed cluster treatment sites where MHC staff identifies archaeological sensitivity.

HPCC/C2. Consistent with MPS HPCC1.3 (Archaeological Sites), if any archaeological sites are identified during survey work, the Applicant shall meet with MHC staff and Commission staff to demonstrate how the proposed development has been configured to maintain and/or enhance such resources. In addition, any archaeological sites determined eligible for listing on the National Register of Historic Places shall be preserved and protected from disturbance through a conservation restriction or similar means to be approved by Commission staff and MHC staff prior to issuance of a Preliminary Certificate of Compliance by the Commission, and prior to issuance of a local Building Permit, and prior to commencement of construction for that project phase.

HPCC/C3. Existing and proposed conditions plans shall be submitted to MHC for review as each phase of the project is developed. Any above ground structures proposed within the Old Kings Highway Historic District shall be designed consistent with district standards and shall require review and approval by the Orleans Old Kings Highway Historic District Committee and

by MHC staff prior to issuance by the Commission of a Certificate, prior to issuance of a local Building Permit, and prior to commencement of construction for that project phase.

Transportation Conditions

TRC1. To address concerns outlined in Finding TRF4 about post-construction roadway conditions, prior to issuance by the Commission of a Final Certificate of Compliance for each project phase of construction involving the disturbance of any private or public road Right of Way, the Applicant shall restore all disturbed roadways to an equal or better than original condition.

SEE NEXT PAGE FOR SIGNATURES

ISSUANCE OF DECISION

The Cape Cod Commission hereby approves with conditions the application of the Town of Orleans for the Development of Regional Impact as outlined in this decision pursuant to Sections 12 and 13 of the Act, c 716 of the Acts of 1989, as amended for the proposed Orleans Comprehensive Wastewater Management Plan.

10/13/11

Peter Graham
Commission Chair

Date

COMMONWEALTH OF MASSACHUSETTS

Barnstable, ss

Oct 13, 2011

Before me, the undersigned notary public, personally appeared

Peter Graham in his/her capacity as Chairman of the Cape Cod Commission, whose name is signed on the preceding document, and such person acknowledged to me that he/she signed such document voluntarily for its stated purpose. The identity of such person was proved to me through satisfactory evidence of identification, which was [_] photographic identification with signature issued by a federal or state governmental agency, [_] oath or affirmation of a credible witness, or [✓] personal knowledge of the undersigned.

Gail P. Hanley
Notary Public

My Commission Expires: 9-28-18

GAIL P. HANLEY
Notary Public
COMMONWEALTH OF MASSACHUSETTS
My Commission Expires
September 28, 2018

Exhibit A - Adaptive Management Plan Scope

The decisions for Adaptive Management of the plan's implementation shall be based upon the review and evaluation of the monitoring and implementation conditions outlined above. The Town shall establish a technical review committee comprised of representatives including, but not limited to, the Town, DEP and Cape Cod Commission. The TRC shall meet as required to review the plan's implementation status and monitoring components and provide input to the Town's decisions for next steps. Items to be considered as part of the Adaptive Management Plan include but are not limited to:

- Implementation of Plan
- Documentation of capital expenditures
- Compliance with the groundwater discharge permit
- Monitoring Required by DRI Decision
- Reporting on Estuary water quality monitoring
- Summary of habitat assessments that may be completed by the Town, MassDEP, regional organizations, or others
- Coordination with the Towns of Brewster and Eastham
- Potential evaluations and changes as needed
- MEP Scenario runs

The primary purpose of the AMP is to insure expedited TMDL compliance and cost-effective achievement of the Town's CWMP goal to restore impaired marine and fresh water quality and habitat. The CWMP will achieve this goal by providing wastewater infrastructure and opportunities for regional participation over the course of the next 25 years, supplemented by the non-structural plan. There are several monitoring and evaluation components of the AMP:

Implementation Progress Reports– measuring progress
Monitoring and reporting on the progress of the plan will ensure that the CWMP is implemented. Major milestones for the project as described in the CWMP and Water Resource Finding 16 are:

•Complete CWMP Early 2011
•Secure Preliminary Design Funds 2013 Spring
•Preliminary Design Resolutions and Engineering
•Secure Construction Funds 2015

•Phase 1 Construction 2015 to 2017
•Start-up of Phase 1 facilities mid 2017
•Phase 2 2018-2020
•Phase 3 2021-2023
•Phase 4 2024-2026
•Phase 5 2027-2029
•Phase 6 2030-2032

The following items shall be included for measuring progress on the plan's implementation including milestones where appropriate. Regular Adaptive Management Plan Progress Reports shall be submitted to the Commission every 2 years from the effective date of this Decision, and include the following:

1) Capital Expenditures to date
2) Amount of sewered area
3) Percent nitrogen removed from watersheds
4) Comparison to TMDL target amounts
5) Planned Capital Expenditures
6) Projected Expansion areas to be serviced in the next two years
7) Status of regional watershed management opportunities

The Project Evaluation Form submitted to DEP for SRF purposes shall be submitted concurrently to the Commission.

Groundwater Discharge Permit

Monitoring according to the GWDP is another component of review that will ensure the treatment facility is complying with its treatment goals and compliance with the Regional Policy Plan and TMDLs of the receiving waters. Monitoring in the receiving waters downgradient of the facility will ensure that the levels of nitrogen from the facility will be protective of those resources. The AMP will include the following tasks:

- Convene Technical Review Committee, including a Town of Brewster representative as an ex-officio non-voting member to participate for the purposes of review and comment, to review Draft Groundwater Discharge Permit items including the following:
  Evaluate past monitoring
  Identify wells, parameters and frequency of monitoring
  Identify stream monitoring locations for flow and quality
  Identify marine water monitoring locations and frequency
- Scope and conduct a hydrogeologic characterization of the Namskaket Marsh including extent of clay layer to the north and water quality and discreet discharges of groundwater into the Namskaket Creek proximal to the proposed wastewater treatment facility.
- Revise the local groundwater model to incorporate the site specific characteristics and calibrate to measured flows.
- Scope and conduct an ecological habitat survey of the Marsh system proximal to the wastewater treatment facility and creek.
- Provide for baseline measurements and phased-in monitoring in adjacent receiving watersheds based upon phased- in increases of discharge from the facility.
- Reporting to the Commission and Town of Brewster Biennually
  WWTP –Flow Rate – measured daily & monthly with averages
  WWTF - Water quality-influent/effluent monthly
  Monitoring Wells - Annually
  Groundwater quality –parameters such as
  ammonia and alkalinity should be added.
  TOC and PCPPs should be monitored annually
  Water Table Elevations to evaluate mounding
  Stream flow - continuous stage recorder
  - water quality
  Marine Water quality at Sentinel Stations -seasonally

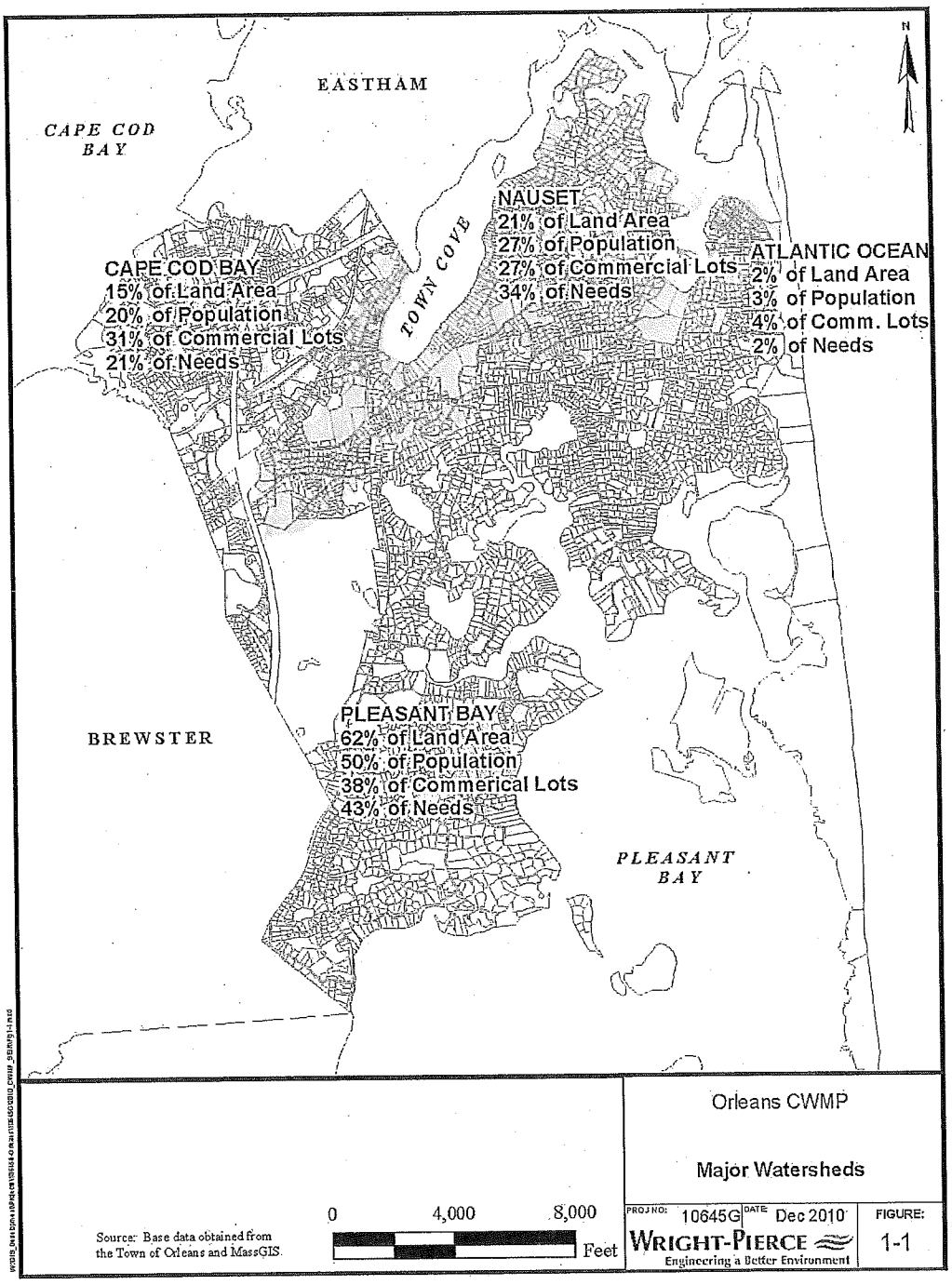
Marine Water Quality and Habitat
Monitoring of marine waters in the targeted watersheds which presently exceed nitrogen-TMDLs will provide confirmation that the project's goals are ultimately met.

- Surface Water Quality– Seasonally with Report submitted at a frequency to be decided by the TRC but no less than every 5 years
  Marine – Sentinel Stations
  Others to be determined by the TRC (Streams, tributaries...)
- Habitat
  Eelgrass – Mass DEP has on-going regional program for baseline
  Benthic - to be decided by the TRC but no less than every 5 years
  Marsh - Ecological habitat

Non Structural Management, (as appropriate for demonstrating achievement of related CWMP goals)

Fertilizer Management
Stormwater management
Land use controls
Freshwater ponds – sewering in watersheds, in-pond restoration, monitoring
Enhance Natural Attenuation and/or Tidal Flushing
Alternative and Innovative Technology

Orleans Shared Coastal Watersheds



Coastal Water Quality Monitoring Stations (not including Nauset Marsh)

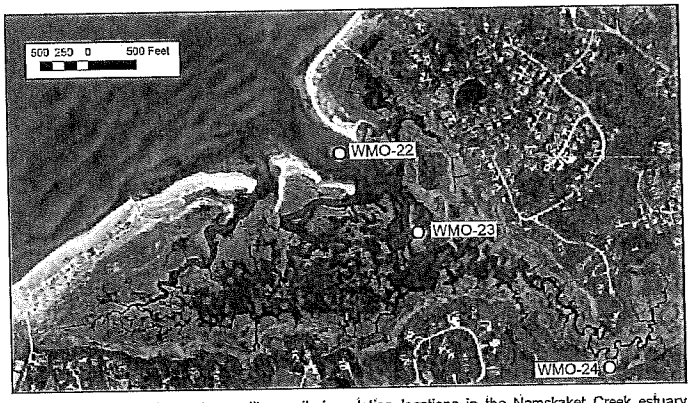


Figure VI-1. Estuarine water quality monitoring station locations in the Namskaket Creek estuary system. Station labels correspond to those provided in Table VI-1.

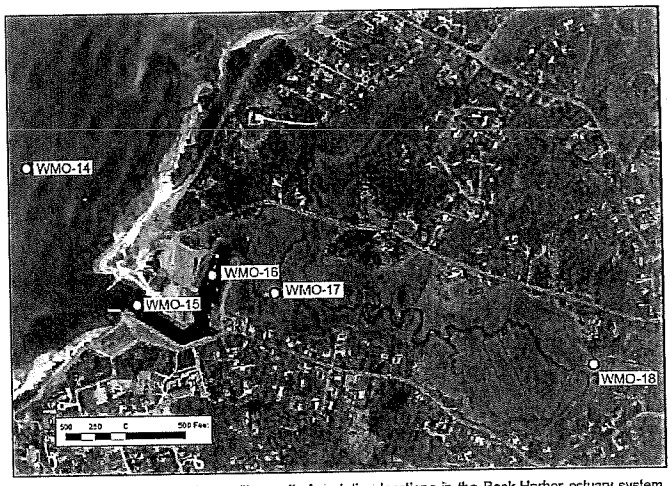


Figure VI-1. Estuarine water quality monitoring station locations in the Rock Harbor estuary system. Station labels correspond to those provided in Table VI-1.

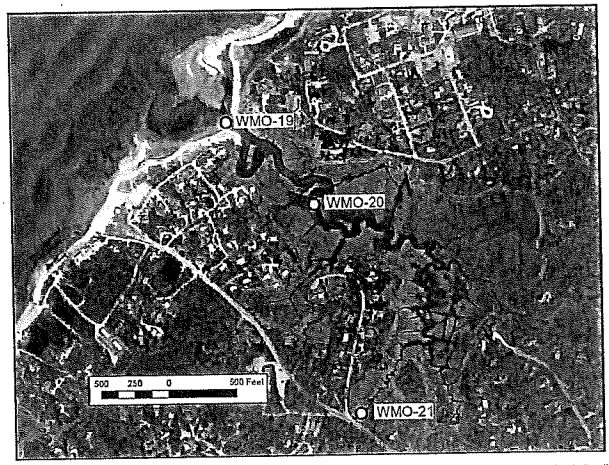


Figure VI-1. Estuarine water quality monitoring station locations in the Little Namskaket Creek estuary system. Station labels correspond to those provided in Table VI-1.

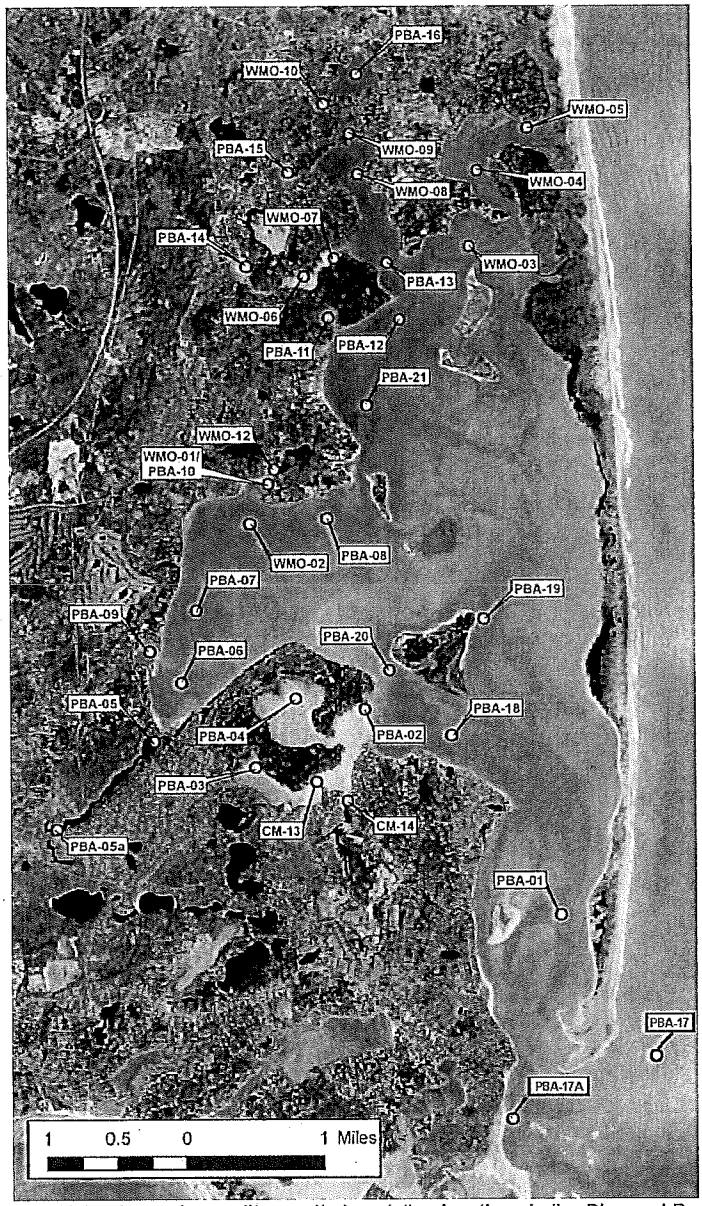




Figure VI-1. Estuarine water quality monitoring station locations in the Pleasant Bay estuary system. Station labels correspond to those provided in Table VI-1.

ATTACHMENT C

ORLEANS WATER QUALITY ADVISORY PANEL CONSENSUS PLAN

Orleans Water Quality Advisory Panel
Consensus Agreement of the OWQAP
March 11, 2015*

The Orleans Water Quality Advisory Panel, or OWQAP, was convened to guide studies and assessments, define preferred approaches, seek consensus and build widespread community support for a customized, affordable water quality management plan for the Town of Orleans. 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. It is staffed and assisted by Water Resources Associates, Stantec and its consultants, and the Consensus Building Institute (CBI).

The OWQAP has met for twelve half-day meetings since July 2014, all of which were open to public attendance and comment. After examining a broad range of options, the Panel has reached agreement on a set of principles and some key elements of an Amended Water Quality Management Plan (the Plan) and associated Adaptive Management Plan[1]. This Agreement includes and requires successful completion of the steps described here to resolve uncertainties and confirm key elements, such as treatment and disposal site suitability and availability, development of demonstration sites for non-traditional (NT) technologies, and further work to find an equitable distribution of costs necessary to the development of an acceptable and executable engineering plan that adheres to the key elements.

Agreed Goals and Objectives:

1) The Plan seeks to improve water quality in Orleans' natural water systems, meet nitrogen reduction targets and other key requirements of local, regional, State and Federal regulators, including finalized and preliminary TMDLs, while supporting updating of the analysis of current water quality conditions and MEP model runs. The Plan includes flexibility within an adaptive management framework to allow changes in the implementation plan to respond to any new findings from these updated analyses and resolution of other uncertainties.

2) In addition to needed nitrogen reduction, the Plan seeks to control phosphorous impacts on freshwater systems, address sanitary requirements, and respond to commercial and residential wastewater needs. The Plan also seeks to restore natural ecosystem services[2] using in-situ NT water quality solutions that offer rapid restoration, improve water and sediment quality, and restore habitat health.

3) The Plan also seeks affordability and fairness in its distribution of costs, by developing a detailed Financial Plan for allocations of costs, as well as a commitment to working together to identify and pursue all sources of grants and other financial support.

Agreed Plan Approach and Key Elements:

4) Given the potential benefits of NT technologies for removing nitrogen and phosphorous and providing valuable ecosystem services with more rapid results and at lower cost than traditional collection systems, the intent of the Plan is to maximize the use of Coastal Habitat Restoration[3] (CHR), Aquaculture[4], Floating Constructed Wetlands[5] (FCW), Permeable Reactive

[1] This Plan will amend the approved CWMP approved by the Cape Cod Commission and MassDEP in 2011.

[2] Natural symbiotic processes conducted by one species and benefitting other(s).

[3] Creating habitats including shellfish reefs (such as the oyster reefs created in Wellfleet) that restore natural ecosystem services in the water body. The shellfish remove nitrogen from the water, and a bio-diverse ecosystem of many other species also contribute to nitrogen reduction. The reefs support young fish, crabs and other bottom dwelling animals, and sustain or restore the submerged aquatic vegetation (SAV) and benthic conditions necessary for natural habitat functions.

Barriers[6] (PRBs) and other approaches (e.g., inlet management) as strategies for meeting water quality goals. While there are risks and much to learn about these technologies, the *Conceptual Approach to Meet Orleans Water Quality Goals Map* estimates technologies and sizes within each watershed that could reasonably be implemented to help meet TMDLs and water quality needs. If fully successful, this could include realizing up to two-thirds of the Town's nitrogen reduction using NT technologies. A first phase of work to further evaluate the effectiveness, costs, risks, and opportunities for these NTs will be to select, design, and implement a series of demonstration projects. The findings from demonstration projects will be used to determine locations and areal extents of NT solutions, as well as their expected costs and contributions to nitrogen and phosphorous removal goals.

5) The Plan reduces the sewered footprint (area of town and number of properties to be sewered) to a minimum by maximizing the use of the non-traditional technologies referenced above. The Conceptual Approach delineates two footprints within Orleans for implementation of sewers. These areas include 1) ~280 parcels encompassing Downtown Orleans (~100,000 GPD), to be treated at a new treatment plant located at the Tri-Town site and disposed at one of several prospective sites nearby (potentially also using a reclaimed water system), and 2) ~360 parcels within the Meetinghouse Pond sub-watershed (~50,000 GPD), to be treated at a satellite treatment facility and disposal area to be identified. These areas were designated for wastewater collection and treatment because their nitrogen reduction requirements and wastewater needs could not be met using only NT technologies. The Downtown area includes numerous properties with aging and/or non-compliant systems and inadequate nitrogen reduction, which cannot be cost effectively retrofitted to meet current wastewater needs. Certain newer facilities may be "grandfathered" for some limited period of time. Options utilizing small cluster plants downtown were found not to have an economic advantage and the additional complexity involved in ownership, operation and maintenance of several small plants was a significant disincentive. Satellite or cluster treatment plants are valid wastewater treatment options in the appropriate circumstances and will be evaluated for other locations within Orleans.

6) In Meetinghouse Pond watershed, 100% nitrogen removal is required. Technology performance limitations and land use constraints in Meetinghouse Pond prevent deployment of sufficient NT solutions to meet those needs. The Plan includes siting a satellite treatment plant for the Meetinghouse Pond watershed.

7) The new treatment facility will be designed to treat septage from the towns currently served by the existing Tri-Town Septage Treatment Plant, as well as the wastewater from the downtown Orleans area only. Septage storage and treatment capacities will be evaluated for appropriate sizing, to avoid competition based on tipping fee / price. This will allow the town to continue to meet the septage treatment needs of the businesses and residents of Orleans and the Lower/Outer Cape, while generating net positive revenue that will lower customer rates in Orleans. Revenues from septage treatment will be allocated to those parties who contribute to the capital cost and Orleans will seek compensation for providing nitrogen treatment and disposal for flows from out-of-town customers.

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[4] Shellfish farming: the shellfish are filter feeders that remove nitrogen form the water system. The shellfish are harvested for market.

[5] Floating structures filled with plants that use nitrogen and other nutrients from the water to grow.

[6] PRBs intercept groundwater before it reaches the coastal water system and provide the necessary conditions for the conversion of nitrogen compounds to harmless nitrogen gas. The process is called denitrification.

8) The Plan includes an Adaptive Management Plan (AMP), which will provide a detailed approach to monitoring the success and efficacy of each component of the Plan and a framework and methodology for evaluating and adjusting solutions over time, with back-up technologies (including possibly additional sewering) to ensure compliance with regulatory requirements for water quality. The AMP will also provide for continued coordination with regulatory agencies to confirm compliance of the Plan with monitoring standards and water quality requirements, and continued monitoring of the financial and economic impacts of the plan on residents and businesses of Orleans. The AMP will also provide a framework for selecting, implementing and evaluating NT demonstration projects to refine initial assumptions about effectiveness, cost, and other implementation considerations. The *Conceptual Approach to Meet Orleans Water Quality Goals* will be updated and refined based on information developed through demonstration projects and other studies and analyses.

9) The Plan and AMP will seek to capitalize upon opportunities for potential management synergies and cost savings through cooperation with Orleans' neighboring towns of Eastham and Brewster.

OWQAP Commitment:

10) By agreeing to these principles and key features of an Amended Water Quality Management Plan, OWQAP Stakeholder Representatives endorse the goals, objectives, approach, and key elements as described above, and commit to support Warrant Articles, By-laws, and other Town measures to pursue and implement the Plan and its underlying principles. Representatives also agree to inform and engage their full stakeholder groups and related constituencies about these components and principles.

11) OWQAP Stakeholders also agree to work to refine and implement Adaptive Management in a manner consistent with these principles and with the Plan, and to work collaboratively to address challenges encountered in the process of resolving uncertainties in the Plan and to work collaboratively to finalize an executable engineering plan that is consistent with the principles of the Plan.

CONSENSUS of the Orleans Water Quality Advisory Panel is defined in their approved Operating Protocols as unanimous concurrence of the Stakeholder Representatives, representing their constituencies. Members may also "abstain." Abstaining means not offering consent or endorsement, but also not blocking an agreement. Abstaining members are not counted in determining if consensus has been reached.

Sims McGrath, Orleans Selectman
Alan McClennen, Orleans Selectman
David Dunford, Orleans Selectman
Jon Fuller, Orleans Selectman (in absentia)
Judith Bruce, on behalf of the Former CWMP Committee
Dale Fuller, on behalf of the Orleans Taxpayers Association
Jim McCauley, on behalf of the Orleans Pond Coalition
Sid Snow, on behalf of the Orleans Chamber of Commerce
Jeff Eagles, on behalf of the Orleans Water Alliance
Doug Fromm, on behalf of Orleans CAN
Peter Haig, on behalf of the Orleans Community Partnership
Abstention by Mark Fiegel, on behalf of the Citizens Peer Review Committee

ATTACHMENT D

RESPONSE TO COMMENTS

Table Q-1. 2010 CWMP/SEIR Comments and Responses to Comments

Agency	*Summary of Comment*	*Response*
EEA	Review the Final Massachusetts Estuaries Project (MEP) Report for Nauset Marsh to determine if any changes to the CWMP are needed to address nutrient loading and water quality issues affecting Nauset Marsh/Town Cove.	In a September 2023 Pre-Filing meeting, MassDEP explained that the TMDL for the Nauset had not been established yet due to uncertainty and requirements for additional modeling. The current MEP modeling is out of date. MassDEP acknowledged that there are upcoming studies and regional efforts and regulations that will affect the understanding of nutrient removal requirements. (Attachment E). Therefore, the revised sewer phasing approach is based on the nitrogen removal goals in the 2012 MEP DEP Report (Howes et al., 2012). The Adaptive Management approach outlined in Section 5 allows future adjustments as needed once DEP updates the Nauset Harbor nitrogen removal goals.
	Conduct confirmatory modeling with Linked Water Quality Model to identify estimated nitrogen reductions to be achieved.	The Pleasant Bay Alliance, member towns, and UMass Dartmouth School for Marine Sciences and Technology worked together to update the Pleasant Bay Massachusetts Estuary Program (MEP) model. The results showed that the nitrogen removal strategies in the PBA Targeted Watershed Management Plan would meet TMDL thresholds and that alternative scenarios would also meet the TMDL (Howes et al., 2021). For the Nauset Harbor MEP, MassDEP has acknowledged that updated water quality data and revisions to the model are needed. The TMDL for the Nauset watershed has not been established yet due to uncertainty and requirements for additional monitoring. DEP agrees that realistic nitrogen load reductions need to be developed, and therefore, the Town has not utilized the model to estimate nitrogen reductions to be achieved (Attachment E).
	Conduct additional modeling to confirm the impacts of discharge to Little Namskaket Marsh.	The treated wastewater effluent discharge location was revised and is now at 32/43 Lots Hollow Road via wick wells. Additional modeling was provided to MassDEP as part of the application for approval of the Hydrogeological Investigation at 32/43 Lots Hollow Road, which MassDEP approved. Refer to ACWMP Section 3.1 and Attachment F.

	Conduct additional monitoring and characterization of the existing Tri-Town plume.	USGS continued to monitor and filed a final report to the Town in October 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen (USGS, 2016). Refer to ACWMP Section 5.6.
	Re-evaluate cluster systems for Cedar Pond.	Parcels contributing to Cedar Pond were sewered during Phase 1.
	Prepare annual TMDL Compliance Report.	The Town of Orleans is part of the Pleasant Bay Alliance and the associated Watershed Permit. As part of the Watershed Permit, PBA prepares annual reports regarding efforts to reduce nitrogen loading within the estuary, with the goal of TMDL compliance.
	Conduct monitoring for and address treatment of CECs.	The WWTP was not designed to address CECs as this was not required by MassDEP.
	Prior to any work in Wetland Protection Act (WPA) Resource areas, a submittal must be made to the Orleans Conservation Commission.	The need for filing with the Conservation Commission is noted. To date, Notices of Intent (NOIs) have been filed for Phase 1 and Phase 2 sewering, and Order of Conditions have been obtained. A Request for Determination of Applicability (RDA) was filed for the construction of the Wastewater Treatment Facility, and a negative Determination was obtained. During future design phases, efforts will continue to be made to avoid wetland resource area impacts.
	Confirm that the core components of the proposed program do not require a MassDEP Chapter 91 License.	Permitting requirements will be confirmed as each phase moves from the planning into the design phase. It is currently anticipated that no Chapter 91 License will be needed.
	Work closely with MA NHESP to minimize impacts to rare species from all project components.	The relocation of the effluent discharge from the WWTP site to 32/43 Lots Hollow Road reduced impacts to NHESP Estimated/Priority Habitat. Permitting requirements for future phases will be confirmed during design, however, impacts to NHESP-protected habitat are currently anticipated to be limited to work in existing roads.
	Submit final design plans to MHC for assessment of the potential for impacts to historic and archaeological resources.	The Town has coordinated with MHC during the design and construction work for Phases 1 and 2 and will continue to coordinate with MHC as needed for future phases.

	Consider DOER comments regarding greater CO2 reductions via alternative nitrogen demand technology and incorporate measures to increase energy efficiency.	Greenhouse gas emissions and energy efficiency will be confirmed as the project moves from the planning phase into the design phase. They have been considered for completed phases and will continue to be considered during the design of future phases. Refer to ACWMP Section 7.4 – Executive Order 569.D.
	Adopt by-laws, regulations, and policies to limit new growth prior to the installation of new sewers.	Amended CWMP Section 5.9.2 discusses the Nitrogen Bylaw that Orleans has adopted. The Town developed a Fertilizer Nitrogen Control bylaw that passed at the 2014 Annual Town Meeting. The purpose of the bylaw is to regulate the use of nitrogen and phosphorous-based fertilizers within the Town.
	Additional wastewater disposal sites may be required to accommodate future wastewater flows from the "Expanded Program" outside the "Core Area."	In addition to the existing wick well discharge at 32/43 Lots Hollow Road that can accept 500,000 gpd of effluent discharge, MassDEP has also approved the Hydrogeological Investigation at the Route 6 Cloverleaf and Beach Road sites (Attachment F). In the future, if needed, Orleans will seek additional groundwater discharge authorization for these sites.
	Work with Brewster, Eastham, MassDEP, Cape Cod Commission, Pleasant Bay Resource Management Alliance, and Cape Cod Water Protection Collaborative regarding regional solutions to water quality issues.	CCC, PBA, DEP, Brewster, and Eastham were part of OWQAP monthly meetings and engaged in plan development and agreement. Eastham and Orleans have entered into an MOU (Attachment S). The Town of Brewster is part of the PBA with Orleans and has entered into the Pleasant Bay Targeted Watershed Permit with Orleans, ACWMP Section 5.3.2. CCC provided a Consistency Review and Letter in 2015 on the Consensus Plan. Regional Coordination in ACWMP Section 5.10. MassDEP and CCC have been involved in the ACWMP development process (Sections 7.2 and 7.3).
	Use lower emission equipment and require contractors to retrofit diesel equipment and on-road Low Diesel Fuel.	Contractors are required to comply with the MassDEP Diesel Retrofit Program.
	Use Ultra Low Sulfur Diesel (ULSD) fuel to reduce emissions of fine particulate matter.	. All non-road engines will be operated using only ULSD with a sulfur content of 15 or less ppm.

	All refueling and maintenance should be on pavement and outside of sensitive areas.	. Equipment will be refueled outside of any wetland resource areas or Buffer Zone and conducted with a pumped system and spill containment on hand.
	Develop a spill contingency plan.	. A spills contingency plan addressing prevention and management of potential releases of oil and or hazardous materials from pre- and post-construction activities will be presented to workers at the site and enforced.
	Incorporate Massachusetts Estuaries Project Total Maximum Daily Loads for Nauset Marsh and Rock Harbor and revise approach to meet mandated load reductions.	d. The TMDL for the Nauset and Rock Harbor watersheds have not been established yet due to uncertainty and requirements for additional monitoring. DEP agrees that realistic nitrogen load reductions need to be developed, and therefore, the Town has not utilized the model to estimate nitrogen reductions to be achieved (Attachment E).
MassDEP	If any work involves temporary or permanent alteration to Wetland Protection Act (WPA) Resource areas, a submittal must be made to the Orleans Conservation Commission.	The need for filing with the Conservation Commission is noted. To date, Notices of Intent (NOIs) have been filed for Phase 1 and Phase 2 sewering, and Order of Conditions have been obtained. A Request for Determination of Applicability (RDA) was filed for the construction of the Wastewater Treatment Facility, and a negative Determination was obtained.
	Coverage under the US EPA NPDES Construction General Permit (CGP) is needed for any disturbance of one or more acres.	Coverage under the NPDES CGP was obtained for Phases 1 and 2 and will continue to be obtained for future phases.
	Further characterization of the wastewater plume from the prior Tri-Town Septage Treatment Facility is needed.	USGS continued to monitor and filed a final report to the Town in October 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen (USGS, 2016). Refer to ACWMP Section 5.6.
	Orleans should commit to evaluating available and effective energy efficiency as design and permitting progress.	Greenhouse gas emissions and energy efficiency will be confirmed as the project moves from the planning phase into the design phase. Energy efficiency measures have been considered for completed phases and will continue to be considered during the design of future phases. Refer to ACWMP Section 7.4 – Executive Order 569.D.

	Orleans must consider the potential for encountering contamination during excavation.	The Town has and will continue to monitor excavated areas for potential contamination and will retain the services of an LSP as needed.
Cape Cod Commission	Coordinate with MHC regarding the potential impacts on historical/archaeological resources and report findings during construction.	MHC was consulted during the design of Phase 1 and Phase 2 and will continue to be consulted during the design of future phases. The new WWTF is within the footprint of the former Tri-Town Facility which has undergone extensive archaeological study and investigations.
David Farquar	Raised concerns regarding the accuracy of Massachusetts Estuaries Project reports and the need to consider the National Academy of Scientists report.	Refer to ACWMP Section 5 - Adaptive Management Plan.
	Need to further evaluate the Tri-Town Septage Treatment Facility before discharging additional effluent from a new WWTF.	The Tri-Town Septage Treatment Facility has since been demolished. USGS continued to monitor the Namskaket Marsh effluent plume and filed a final report to the Town in October 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen (USGS, 2016); refer to ACWMP Section 5.6.
	Decentralized cluster systems should be evaluated instead of town-wide sewering. A Citizens Petition signed by 1000+ citizens was cited as this document had not been previously addressed in the EIR.	Cluster systems are still under consideration in some locations; refer to ACWMP Section 5.11.
	The Nauset Estuary MEP Report is overdue. However, this receiving water body also requires nutrient reduction.	The Nauset Harbor MEP Report was issued in 2012, and like Pleasant Bay, Orleans is using the MEP Report as a guide. Still, the adaptive management approach allows for changes in the future as new information becomes available. DEP has acknowledged that an update to the Nauset Harbor MEP Report is needed. The TMDL for the Nauset watershed has not been established yet due to uncertainty and requirements for additional monitoring. DEP agrees that realistic nitrogen load reductions need to be developed. (Attachment E).

Clean Water Action	Lack of sufficient alternatives analysis to the proposed centralized sewer and treatment plant.	Cluster systems are still under consideration in some locations; refer to ACWMP Section 5.11. In addition to centralized sewer and treatment, Non-Traditional Technologies have been considered as described in the ACWMP Section 4, and as discussed therein, aquaculture and Permeable Reactive Barriers are proposed in addition to traditional wastewater infrastructure.
	Concern over the overwhelming cost of the proposed system in the face of more affordable alternatives.	See ACWMP Section 6 regarding funding that the Town will use to implement the ACWMP.
	Insufficient spending on objective, science-based determination of the scope of the problem, especially in light of a proposed National Academy of Sciences comprehensive study for Cape Cod.	The Pleasant Bay Alliance, member towns, and UMass Dartmouth School for Marine Sciences and Technology worked together to update the Pleasant Bay Massachusetts Estuary Program (MEP) model, and the results showed that the nitrogen removal strategies in the PBA Targeted Watershed Management Plan would meet TMDL thresholds and that alternative scenarios would also meet the TMDL (Howes et al., 2021). For the Nauset Harbor MEP, MassDEP has acknowledged that updated water quality data and revisions to the model are needed. The TMDL for the Nauset watershed has not been established yet due to uncertainty and requirements for additional monitoring. The Town's Adaptive Management approach (ACWMP Section 5) allows for revisions to the approach for nitrogen removal as new information becomes available.
	Insufficient groundwater modeling in the area where treatment plans effluent will be released under the current plan.	The effluent discharge location has since been moved to 32/43 Lots Hollow Road. The discharge at 32/43 Lots Hollow Road was assessed via a hydrogeologic model, which was approved by MassDEP.
	Insufficient consideration of treatment techniques for Contaminants of Emerging Concern (CECs) such as pharmaceutical and personal care products, which the Silent Spring Institute has been researching in various drinking water resources.	CEC removal was included in the OWQAP's Technology Evaluation Decision Support Tool Evaluation Matrix. However, the WWTP on Overland Way has not been designed to address CECs as this was not required by MassDEP.

	The potential for a greatly imbalanced financial burden to be borne by low- or fixed-income individuals and families living in Orleans, as increases in taxes and rates at the local level will finance the greatest proportion of "improvements" made over the next few years. Additionally, Operations and Maintenance costs will persist, and property values for expensive, coastal homes stand to gain greatly over smaller, inland homes of Cape Cod's working class.	See ACWMP Section 6 regarding funding that the Town will use to implement the ACWMP.
Orleans Pond Coalition	The Orleans Pond Coalition supports the Orleans CWMP.	Comment acknowledged. No response is needed.
Alan McClennen	This comment letter generally expressed support for the 2010 CWMP and encouraged the Cape Cod Commission and EEA to approve the Town's approach.	Comment noted and no response needed; as noted in the NPC and ACWMP, some revisions have occurred to the original CWMP wastewater management approach.
Ben Buck	This comment letter expressed concern regarding the existing nitrogen plume from the Tri-Town Septage Treatment Facility. The need to evaluate alternatives was emphasized.	Disposal site investigations are in ACWMP Section 3.1. The use of Non-Traditional Technologies, ACWMP Section 4, summarizes alternatives to traditional technologies.
	Concern was expressed regarding CWMP-proposed discharge of wastewater effluent to Namskaket Marsh via rapid infiltration beds at the new wastewater treatment plant site. The need to evaluate alternatives was emphasized.	The treated wastewater effluent discharge location was revised and is now at 32/43 Lots Hollow Road via wick wells. Refer to ACWMP Section 3.1.

Bev Carney	Town of Orleans should revisit and revise the proposed sewer phasing.	As of 2023, the sewer service areas have been updated and the phasing plan has been revised. Instead of six phases, the ACWMP assumes implementation of sixteen phases based on consideration of priorities for nitrogen removal as well as sewer connectivity and associated construction logistics. The updated service areas also provide the Town with flexibility for scheduling and combining areas, depending on funding availability and other Town priorities.
	The proposed CWMP is not environmentally sound due to the proposed effluent discharge into Namskaket Marsh and the abandonment of the existing regional facility.	The treated wastewater effluent discharge location was revised and is now at 32/43 Lots Hollow Road via wick wells; refer to ACWMP Section 3.1. The sewer phasing has been revised, and Phases 1 and 2 are complete/in construction; refer to ACWMP Sections 3.3 and 3.4. As discussed in Section 3.7, the Tri-Town Septage Facility has been decommissioned, and its regional septage receiving function is provided at the new WWTF.
	There is concern about impacts to the Eastern Box turtles.	As of the 2018 NPC, the effluent discharge location was moved to 32/43 Lots Hollow Road, which is farther from the mapped NHESP Estimated and Priority Habitat as compared to the previous parcel 1/1A site. Additional consultation with NHESP will occur as needed during future implementation phases of the project to identify and mitigate any potential impacts.
	There is concern about cost of the plan.	See ACWMP Section 6 regarding funding that the Town will use to implement the ACWMP.
	Wondering if and when Bakers Pond will be sewered.	Refer to ACWMP Section 3.2 for updated sewering Phases. Bakers Pond is outside of the “Core Area” and is not planned to be sewered; refer to ACWMP Section 5.8.4.
	The tri-town district has not weighed in on plumes, permit renewal, and the future.	Tri-town Facility has been decommissioned (ACWMP Section 3.7). Coordination between Orleans, Eastham, and Brewster can be reviewed in ACWMP Section 5.10.
	What level of treatment will be provided at the WWTP and how much freshwater dilution is needed to achieve projected nitrogen discharge levels?	The WWTP on Overland Way is designed to achieve a nitrogen concentration of 10 mg/L in the effluent discharge, in compliance with the MassDEP Groundwater Discharge Permit. However, the plant to date has routinely been achieving a concentration of less than 5 mg/L. No dilution is required to achieve these concentrations.

	What was the minimum GPD that will be generated by the Wright-Pierce plan?	This comment is no longer applicable. The Wright-Pierce plan has been superseded.
	Clarify what SE DEP meant when Town Cove and Nauset Estuaries data, reports, etc., were "in the wings."	Town Cove and Nauset Estuaries studies were ongoing at the time this comment was received. They have since been completed and can be found in references Howes et al. 2012, 2021.
Town of Brewster	Concern has been expressed regarding the discharge of treated effluent into Namskaket Marsh.	USGS continued to monitor the Namskaket Marsh effluent plume and filed a final report to the Town in October 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen (USGS, 2016); refer to ACWMP Section 5.6.
	All towns within the Pleasant Bay watershed need more specific information regarding the amount of Pleasant Bay TMDL each of the towns in the watershed is responsible for.	Since the 2010 CWMP, Brewster has joined the Pleasant Bay Alliance Watershed Permit, and the associated Targeted Watershed Plan identifies each Town's nitrogen removal responsibilities. Refer to Section 5.3.
	The long-range plan to have the wastewater from all the sewered areas in the town treated at the current Tri-town site would result in an inter-basin transfer from the Pleasant Bay watershed to the Namskaket Marsh Estuarine watershed.	Per 313 CMR 4.05(1), "Extending water of wastewater services within a city or a town and between two or more River Basins" is not considered an increase in the Present Rate of Interbasin Transfer "as long as the transfer does not cross the municipal boundary." The project qualifies under this exemption and is thus not considered an increase in the Present Rate of Interbasin transfer.
	Investigate the Bio-mag process, which may be able to achieve Level 2 high nitrogen removal effluent with less energy.	Biomag is a ballasted floc technology that, by providing improved biomass settling characteristics, is primarily used to increase biomass inventory in existing bioreactor volume. Biomag is most often employed at existing WWTFs when a change in treatment requirements requires additional biomass, and the addition of additional bioreactor volume is made difficult by site constraints. With site footprint not being a constraint at the Overland Road site, there would have been no reason to consider what was then a new and somewhat unproven technology versus a more commonly applied technology such as sequencing batch reactors (SBRs).

	Cost-effective energy design measures should be investigated and implemented during design.	Greenhouse gas emissions and energy efficiency have been considered for completed phases and will continue to be considered during design of future phases. Refer to ACWMP Section 7.4 – Executive Order 569.
Jane Crowley, on behalf of the Eastham Select Board	The Town of Eastham is interested in regional approaches that allow Eastham wastewater to be treated at the new Orleans Wastewater Treatment Facility.	Orleans and Eastham have entered into a MOU regarding collaboration on common issues. Refer to ACWMP Section 5.10 and Attachment S.
Brian and Judy Embleton	Little Namskaket Marsh Plume requires further evaluation.	USGS continued to monitor and filed final report to the Town in October 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen (USGS, 2016). Refer to ACWMP Section 5.6. The effluent discharge location from the new WWTP was modified to discharge via wick wells at 32/43 Lots Hollow Road.
Kevin Cassidy	Little Namskaket Marsh Plume requires further evaluation.	USGS continued to monitor and filed final report to the Town in October 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen (USGS, 2016). The effluent discharge location from the new WWTP was modified to discharge via wick wells at 32/43 Lots Hollow Road. The wick discharge was evaluated with a hydrogeologic model, which was reviewed and approved by MassDEP.
	Decentralized wastewater treatment should be further evaluated.	The 2010 CWMP identified the need for a sewer collection system throughout a significant portion of the Town of Orleans, a new wastewater treatment facility, and an effluent disposal site. The construction of the new 350,000 gpd WWTF began in 2020 and was substantially completed in March 2023. Cluster systems are still under consideration in some locations; refer to ACWMP Section 5.11.
Mary Hartley	Little Namskaket Marsh plume requires further evaluation.	USGS continued to monitor and filed final report to the Town in October 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen (USGS, 2016). Refer to ACWMP Section 5.6. The wick discharge was evaluated with a hydrogeologic model, which was reviewed and approved by MassDEP. Management. Refer to ACWMP Section 3.1.

	Multiple outside reviews/reports do not support the Pleasant Bay TMDL, and the Nauset Estuary Massachusetts Estuaries Program (MEP) Report is not yet available.	The Town of Orleans is using the current TMDL and associated nitrogen removals as a guide in its proposed sewer phasing. However, the adaptive management approach allows for changes as new information becomes available. The Nauset Harbor MEP Report was issued in 2012. Like Pleasant Bay, Orleans is using the MEP Report as a guide, but the adaptive management approach allows for changes in the future as new information becomes available. The TMDL for the Nauset watershed has not been established yet due to uncertainty and requirements for additional monitoring. DEP agrees that realistic nitrogen load reductions need to be developed. (Attachment E), Howes et al., 2012). The MEP Report has been updated as of 2021 (Howes et al., 2021).
Massachusetts Historical Commission (MHC)	Submit final plans for evaluation of potential for impacts to historical and archaeological resources.	MHC was consulted during the design of Phase 1 and Phase 2, and will continue to be consulted during the design of future phases. The new WWTF is within the footprint of the former Tri-Town Facility which has undergone extensive archaeological study and investigations.
MA Natural Heritage and Endangered Species (NHESP)	Consult with NHESP regarding potential impacts to the box turtle.	As of the 2018 NPC, the effluent discharge location was moved to 32/43 Lots Hollow Road, which is farther from the mapped NHESP Estimated and Priority Habitat as compared to the previous parcel 1/1A site. Additional consultation with NHESP will occur as needed during the future implementation phases of the project to identify and mitigate any potential impacts.
Pleasant Bay Alliance	Supportive of approach proposed in SEIR/CWMP; consideration should be given to monitoring and reporting on a regional basis.	The Town of Orleans is part of the Pleasant Bay Alliance and a partner in the associated Watershed Permit and Targeted Watershed Management Plan. Refer to ACWMP Section 5.3.
David Dow, on behalf of Sierra Club, Cape and Island Group	Contaminants of Emerging Concern (CECs) should be addressed.	CEC removal was included in the OWQAP's Technology Evaluation Decision Support Tool Evaluation Matrix. However, the WWTP on Overland Way has not been designed to address CECs as this was not required by MassDEP (2015).

Victoria Reis	Further evaluation of the existing plume toward Little Namskaket Marsh is needed, and the Weiskel report should be considered.	USGS continued to monitor and filed final report to the Town in October 2016 with findings of no evidence of elevated nitrate or total dissolved nitrogen (USGS, 2016). Refer to ACWMP Section 5.6. The effluent discharge location from the new WWTP was modified to discharge via wick wells at 32/43 Lots Hollow Road. ACWMP Section 3.1. The wick discharge was evaluated with a hydrogeologic model, which was reviewed and approved by MassDEP (Attachment F).
	SMAST results in the Massachusetts Estuaries Project report and TMDL accuracy should be reevaluated.	The Town of Orleans is using the current TMDL and associated nitrogen removals as a guide in its proposed sewer phasing. However, the adaptive management approach allows for changes as new information becomes available. The Nauset Harbor MEP was issued in 2012. Like Pleasant Bay, Orleans is using the MEP as a guide, but the adaptive management approach allows for changes in the future as new information becomes available. The TMDL for the Nauset watershed has not been established yet due to uncertainty and requirements for additional monitoring. DEP agrees that realistic nitrogen load reductions need to be developed. (Attachment E) (Howes et al., 2012). The MEP Report has been updated as of 2021 (Howes et al., 2021).

Table Q-2. 2018 NPC Comments and Responses to Comments

Agency	*Summary of Content*	*Response*
Division of Marine Fisheries	Recommends surveys be performed prior to discharge to establish pre-impact baseline.	Refer to Section 5.6 of the Amended CWMP – Water Quality Monitoring.
Coastal Zone Management	More clearly identify where the other 29% of effluent would flow from Lots Hollow Rd. site.	A hydrogeological report was prepared, which focused on determining the maximum discharge capacity of each site and potential impacts from discharges. (Section 3.1 ACWMP) (AECOM, 2018a) Tables 3-1 and 3-2 in the ACWMP show the projected watershed loads at the Lots Hollow Road discharge sites for 5 and 10 mg/l of nitrogen discharge concentrations based on wick discharge rates ranging from 50,000 to 500,000 gpd.
	Describe how the new allocations of treated effluent are consistent with MEP goals regarding N load reductions.	Section 3.2 of the ACWMP provides summary tables of nitrogen load reductions under various scenarios. The Pleasant Bay Alliance, member towns, and SMAST worked together to update the Pleasant Bay Massachusetts Estuary Program (MEP) model, and the results showed that the nitrogen removal strategies in the PBA Targeted Watershed Management Plan would meet TMDL thresholds and that alternative scenarios would also meet the TMDL (Howes et al., 2021). For the Nauset Harbor MEP, MassDEP has acknowledged the TMDL for the Nauset watershed has not been established yet due to uncertainty and requirements for additional monitoring. DEP agrees that realistic nitrogen load reductions need to be developed, and therefore, the Town has not utilized the model to estimate nitrogen reductions to be achieved (Attachment E).
	Summarize in-depth geological studies i.e. where groundwater mixes with surface water.	AECOM's investigations included the installation of soil borings and monitoring wells, grain-size analysis of soil samples, the installation of pumping wells to perform aquifer pumping tests, and the

		installation and testing of a small diameter “test” wick. The data obtained were used to evaluate subsurface conditions (i.e., soils), estimate the groundwater flow direction, estimate hydraulic conductivity values, and to characterize the aquifer’s response to loading the test wick. Results of the field investigations and data analysis were then used to modify the USGS Monomoy Lens groundwater model. Once modified, the groundwater flow model was used to simulate groundwater flow across the site and regionally, estimate groundwater mounding, and estimate the nitrate load to watersheds under various discharge scenarios Section 3.2 of the ACWMP discusses the percent of nitrogen loading going into each receiving watershed.
	Incorporate regionally specific sea level rise projections.	Refer to section 7.4 of the ACWMP. The town will continue to consider the best available data on climate change predictions.
	Include the status of NT, including implementation, lifespan, cost, evaluation metrics, and results.	Refer to Section 4 of ACWMP for NT Technologies and ACWMP Section 6 for costs
Massachusetts Division of Fisheries & Wildlife	The revised effluent discharge location at 32/43 Lots Hollow Road does not occur within estimated habitat of rare wildlife or priority habitat.	No response needed.
MassDEP	For any temporary or permanent alteration in protected areas, a filing with CC under WPA is needed.	The need for filing with the Conservation Commission is noted. To date, Notices of Intent (NOIs) have been filed for Phase 1 and Phase 2 sewering, and Order of Conditions have been obtained. A Request for Determination of Applicability (RDA) was filed for the construction of the Wastewater Treatment Facility, and a negative Determination was obtained.

	Clarify that no additional nitrogen will be introduced to impaired waterbodies without appropriate offset.	This information is in the ACWMP Section 5.3.2.
	No MCP Disposal Sites in the vicinity.	Noted.
	Construction shall not contribute to air pollution due to dust, odor, or noise.	Construction activities will conform to current Air Pollution Control Regulations. Measures will be taken to alleviate dust, noise, and odor nuisance conditions that may occur during the proposed activities.
	Meet EPA tier 4 emission limits or have emissions reduction equipment, keep information on file.	Contractor is required to follow the MA Diesel Retrofit Program. All non-road engines are required to operate using only ultra-low sulfur diesel fuel (ULSD) with a sulfur content less than or equal to 15 ppm pursuant to 40 CFR 80.510.Generators installed to date have met all applicable requirements.
	Have a Spill Contingency Plan – present and enforce.	. A spill contingency plan addressing prevention and management of potential releases of oil and or hazardous materials from pre- and post-construction activities has been developed by contractors engaged for the WWTP, Phase 1 and Phase 2 and presented to workers at the site and enforced; this requirement will continue in future phases.
	Unnecessary idling limited to 5 mins.	Contractors in future phases will be required to limit unnecessary idling
Massachusetts Department of Transportation	Crossing of Route 6 requires Non-Vehicular Access Permit.	Consultation with DOT during design and construction of the Route 6 crossing indicated that a non-vehicular permit was not required, and instead, an alternative DOT Permit was obtained, which included coordination with DOT regarding crossing Route 6 and an associated temporary Route 6 shutdown during construction work.
	No further environmental review is required based on transportation-related issues.	No response needed.
	Traffic Management Plan should be developed.	Contractor responsible for traffic plans.

Massachusetts Historical Commission	Submit final plans for evaluation of potential for impacts to historical and archaeological resources.	The Town has coordinated with MHC during the design and construction work for Phases 1 and 2 and will continue to coordinate with MHC as needed for future phases.

Table Q-3. 2019 NPC Comments and Responses to Comments

Agency	*Summary of Content*	*Response*
Massachusetts Historical Commission	PRBs and Lonnie's Pond aquaculture are unlikely to affect significant historical or archeological resources.	No response needed.
	Submit final plans for evaluation of the potential for impacts to historical and archaeological resources.	The Town has coordinated with MHC during the design and construction work for Phases 1 and 2 and will continue to coordinate with MHC as needed for future phases.
Massachusetts Division of Fisheries & Wildlife	Does not occur within estimated habitat of rare wildlife or priority habitat.	No response needed.
Coastal Zone Management	Supportive of Town's overall approach.	No response needed.
	Continue to evaluate and apply more traditional means of nutrient reduction, such as limiting development, improving septic system denitrification, reducing fertilizer use, and centralized wastewater treatment where appropriate.	The Town investigated a nitrogen reducing biofilters as an enhanced septic system approach, however, has decided not to proceed with this technology; Refer to ACWMP Section 4.4. Growth management and reduction of fertilizers are discussed in ACWMP Sections 5.2 and Section 5.9.2, respectively. Centralized wastewater collection and treatment is proposed throughout much of the Town and described in ACWMP Section 3.2.
Massachusetts Division of Marine Fisheries (DMF)	Shellfish Propagation Permit Required.	Permitting requirements were confirmed. The Town of Orleans has contracted with Ward's Aquafarms to implement aquaculture operations at Lonnie's Pond, and they are responsible for obtaining all required permits.
	Private Shellfish Aquaculture License Required, with certification by MassDMF.	Permitting requirements were confirmed. The Town of Orleans has contracted with Ward's Aquafarms to implement aquaculture operations at Lonnie's Pond, and they are responsible for obtaining all required permits.
	Source reduction strategies are recommended.	The Town of Orleans has implemented source reduction strategies, including stormwater

		management, herbicide controls, and fertilizer reductions. Refer to ACWMP Section 5. 9.
Mass DEP	Activities within areas protected under WPA will require the filing of a NOI with the conservation commission.	To date, only Phase 1 Downtown and Phase 2 Meetinghouse Pond have been designed. An Order of Conditions was received from the Orleans Conservation Commission for each phase and impacts to wetland resource areas were minimized to the extent possible. The design of future sewer lines and pump stations will also avoid floodplains and minimize encroachment on the buffers of wetlands and other protected resource areas to the extent possible. Most sewers and pump stations will be constructed in already existing streets.
	An Amended CWMP should be prepared to provide detail regarding the Town's plan for implementation of Permeable Reactive Barriers and aquaculture.	Refer to ACWMP Sections 4.2 and4.3.
	No MCP Disposal Sites in vicinity.	Noted.
	Construction won't contribute to air, dust, odor, or noise pollution.	Construction activities will conform to current Air Pollution Control Regulations. Measures will be taken to alleviate dust, noise, and odor nuisance conditions that may occur during the proposed activities.
	Meet EPA tier 4 emission limits or have emissions reduction equipment, keep information on file.	Contractor is required to follow the MA Diesel Retrofit Program. All non-road engines are required to operate using only ultra-low sulfur diesel fuel (ULSD) with a sulfur content less than or equal to 15 ppm pursuant to 40 CFR 80.510 .and refueling. Generators installed to date have met all applicable requirements.
	Have a Spill Contingency Plan – present and enforce.	A spill contingency plan addressing prevention and management of potential releases of oil and or hazardous materials from pre- and post-construction activities has been developed by the contractors engaged for the WWTP, Phase 1 and Phase 2 and will be presented to workers at the site and enforced; this requirement will continue in future phases.

	Unnecessary idling limited to 5 mins.	Contractors in future phases will be required to limit unnecessary idling
	Aquaculture facility will not require a Chapter 91.	No response needed.

ATTACHMENT E

MINUTES OF SEPTEMBER 2023 PRE-FILING MEETING WITH MASSDEP AND CAPE COD COMMISSION

Minutes

Meeting name
Pre-filing Meeting with MassDEP and Cape Cod Commission

Meeting date
September 28, 2023

Time
10:00 a.m.

Location
Cape Cod Commission

Project name
Orleans CWMP Update

Attendees:

MassDEP	Cape Cod Commission	Town of Orleans	Wright-Pierce	AECOM
• Millie Garcia-Serrano	• Erin Perry	• Kevin Galligan	• Mike Giggey	• Jennifer Doyle-Breen
• Gerard Martin	• Tim Pasakarnis	• Alan McClennen		• Tim Harrison
• Lealdon Langley		• Judith Bruce		
• Marybeth Chubb		• Ginny Farber		
• Ian Jarvis		• George Meservey		
		• Mike Solitro		

Handouts (attached):

- Annotated Outline (as of 9/25/2023)
- Map of Watershed Boundaries
- Phasing Figure

Meeting Summary:

After introductions Jennifer Doyle-Breen summarized the main points of the Annotated Outline per the meeting agenda. She explained that the purpose of the meeting was to walk MassDEP and CCC through the components of the Town of Orleans Amended CWMP (ACWMP). The ACWMP was required by MEPA and MassDEP through comments on the 2018 and 2019 Notices of Project Change filed for the Town's wastewater management program, which were updates to the 2010 approved CWMP. The following is a summary of additional discussion summarized by topic.

Sewering

- The ACWMP will outline the Town's updated sewer service areas and phasing. The new sewer service areas correspond to the "Core Area" identified in the 2010 CWMP. The revised phasing extends the schedule to service these geographic areas from 2032 as identified in the 2010 CWMP, to 2067. The reason for extending the schedule for sewering the "Core Area" is that the Town has to balance other fiscal municipal responsibilities as well as allow time for consideration of new information in later years, which may affect the sewering plan. The extended time frame also allows for ongoing evaluation and implementation of Non-Traditional technologies, as identified in the CCC 208 Plan and the Town of Orleans 2015 Consensus Plan.

Evaluation of Non-Traditional Technologies

- The Town of Orleans evaluated multiple Non-Traditional (NT) technologies. Only two are being proposed as part of the Towns' approach to management of nitrogen loading: Aquaculture and Permeable Reactive Barriers (PRBs).
- MassDEP asked for some additional description as to why floating constructed wetlands (FCW) and nitrogen reducing biofilters were no longer being considered in Orleans. MassDEP is looking for 'real-life experience' to better understand how these technologies were used. Orleans explained that these technologies are not included in the Town's plan due to siting restrictions, costs (both initial and long-term maintenance), and susceptibility to failure due to events such as

storms. FCW data regarding nitrogen removal quantification was scarce and documentation of nitrogen removal via a Demonstration Project was determined to be very challenging and not worth the cost investment.

- Cape Cod Commission (CCC) maintains a matrix of nutrient control and reduction technologies and approaches. MassDEP asked whether the Orleans feedback would be included in an update. CCC explained that updates are not issued regularly but that the Orleans feedback would be reflected.

Adaptive Management and Flexible Implementation

- Adaptive Management was a component of the 2010 CWMP and will remain an important component of the ACWMP. There are many unknowns and changing conditions that may still affect the Town's proposed wastewater management approach, such as uncertainties regarding nitrogen loading and removal rates; potential revisions to nitrogen removal goals; potential for nitrogen attenuation in certain areas such as Pochet Neck; ongoing PRB feasibility evaluation; effects of climate change; growth, and others. Adaptive Management allows for changes in course based on new information that may develop in the coming decades.
- Orleans is prioritizing water quality improvement infrastructure in the Pleasant Bay watershed, where there is a TMDL, and where there are fewer questions about the impact of natural attenuation. Orleans needs to be sure that Town capital is being spent where it is definitely needed. MassDEP agreed with this approach and acknowledged that there are upcoming studies and regional efforts and regulations that will affect the understanding of nutrient removal requirements.
- Orleans is establishing a proposed phasing plan that will be re-evaluated over time. In addition to the elements listed above, the Town is required to balance the wastewater needs and associated costs against the other needs of the Town. The Town has recently started development of a 20-year Town-wide capital improvement plan; the proposed phasing plan extends beyond that time horizon but is the first Town program to be reflected in it. The intent is to implement a new construction phase as debt from prior Town projects is reduced, approximately every three years.
- Expansion of the wastewater treatment facility (WWTF) is scheduled in the phasing plan. Timing of expansion will be based on actual, measured flows to the WWTF and projected flows from upcoming service areas.
- Upcoming analysis and reporting for the Pleasant Bay Watershed Permit will identify an approach for estimating growth. Communities will need MassDEP buy-in on that approach to keep from getting too far ahead of the curve.For CWMP purposes, the Town plans to project a experienced a growth rate of approximately 5% based on actual growth rate of 3.9% over the past 20 years.
- MassDEP offered to provide a name to participants for someone at the State level to discuss salt marsh attenuation for nitrogen

Filing of Notice of Intent (NOI) under new Title 5 and Watershed Permit Regulations

- Meeting participants agreed that more work needs to be done to understand updated limits and removal requirements for nutrients. MassDEP clarified that the new Title 5 and Watershed Permit regulations only apply to watersheds that have been identified as Nitrogen Sensitive Areas due to the establishment of a nitrogen TMDL or other MassDEP accepted Scientific Evaluation. Pleasant Bay has an established TMDL, but other watersheds in Orleans do not. MassDEP explained that the TMDL for the Nauset watershed had not been established yet due to uncertainty and requirements for additional modeling. DEP agrees that realistic nitrogen load reductions need to be developed and that Nauset Harbor and Rock Harbor embayments will not be designated as Nitrogen Sensitive Areas under Title 5 at this time.
- The Town has asked Wright-Pierce to prepare a letter to MassDEP regarding nitrogen removal requirements and status of regulatory documentation. MassDEP will provide a reply to that letter with direction and any supplemental information.
- The intent of filing the NOI would be to stay the timeframes required by Title 5 for new construction.
- Informal guidance from MassDEP was that assuming no TMDL is in place and barring other MassDEP direction then no IA systems nor NOI are needed.

Coordination with Neighboring Towns

- Orleans has a Memorandum of Understanding (MOU) with Eastham to collaborate on nutrient removal in shared watersheds and has had several formal and informal meetings on this topic.
- Orleans and Brewster have not formalized any partnerships but Orleans has initiated contact with Brewster to begin discussions on collaborative approaches to nutrient removal in shared watersheds..
- Orleans may consider nitrogen and phosphorus credit trading with Eastham and Brewster where it makes sense to do so.

Aquaculture

- Orleans has submitted letter requesting credit for the Town's aquaculture program at Lonnie's Pond and is expecting MassDEP approval of a credit for this NT. MassDEP has not responded to that letter. MassDEP indicated that they would provide a response to the credit request.
- As part of MassDEP's recognition of an aquaculture nitrogen credit, Orleans would like to see a formalized and simplified monitoring protocol developed and recognized. The current monitoring is extensive and expensive. Orleans work has established the feasibility of using aquaculture for nitrogen removal, and as this becomes a standard and recognized MassDEP approach for nitrogen removal, it should be accompanied by a more stream-lined approved monitoring protocol. Orleans offered to propose a standard monitoring protocol.
- Orleans' experience at Lonnie's Pond was identified as a good case study for considerations for location selection, partnership with a commercial fisherman, and evolving relationships with the neighbors. Location selection was influenced by relatively low boat traffic, shelter from storms, and bottom conditions.
- Due to siting constraints, Orleans does not intend to propose additional aquaculture sites as part of its approach to reduce nitrogen loading.

Permeable Reactive Barriers (PRBs)

- Participants discussed how PRBs operate and are sited and designed as well as the high level of effectiveness that has been seen at the pilot study.
- Orleans thanked MassDEP for recognizing PRBs in the 2022 Intended Use Plan and identified that future PRB projects are anticipated to be included in future PEFs.
- Orleans has identified four additional PRB sites that are anticipated to be studied for feasibility and integration with the other water quality improvements.
- Similar to aquaculture, Orleans requested that MassDEP develop a formal credit system for nitrogen removal and that a protocol for evaluating and monitoring be established.
- CCC offered to share a new design manual for PRBs with participants.

Cost

- Meeting participants agreed with the proposed approach to reflect costs in the CWMP.
- It was recognized that the water quality improvement measures were expensive for both the communities and residents. MassDEP recommended that different departments and secretariats be consulted for grants for affordable housing.

Next Steps

- Orleans will be hosting public meetings for the CWMP after the October 16 Special Town Meeting. MassDEP suggested that technologies and approaches be explained simply with a focus on successes and how the public's concerns are being addressed.
- The intent is to submit the draft CWMP by the end of December 2023. MassDEP requested that they be provided notice if issues are anticipated meeting that schedule.
- CCC asked that the Orleans Town Manager send a letter to CCC requesting a 208 consistency review after MEPA review.

Action Item Summary

Ref	Action	Responsible
01	Send MassDEP letter regarding status of nitrogen removal requirements and NOI requirements	Wright-Pierce
02	Issue documentation regarding nitrogen removal requirements and NOI requirements in response to Wright-Pierce letter	MassDEP
03	Complete review of Orleans' aquaculture credit request letter and issue response	MassDEP
04	Provide MassDEP contact/feedback on potential for documenting nitrogen attenuation in salt marsh ecosystems	MassDEP
05	Propose to MassDEP a standardized monitoring system for aquaculture	Orleans
06	Approve standardized monitoring system for aquaculture	MassDEP
07	Provide copy of PRB design manual	CCC
08	Develop and approve standardized monitoring and nitrogen removal credit systems for PRBs	MassDEP

Town of Orleans, MassDEP and Cape Cod Commission

Meeting Agenda

Thursday, September 28, 2023 at 10 a.m.

at Cape Cod Commission Ocean Conference Room

and remote via Microsoft Teams meeting info at

Click here to join the meeting

Meeting ID: 277 476 439 853

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1. Introductions
2. Handouts:
    a. Annotated Outline (as of 9/25/2023)
    b. Map of Watershed Boundaries
    c. Phasing Figure
3. Overview of Orleans Wastewater Management History/DEP Requirement for Amended CWMP (Section 2 of AWCMP Outline)
4. Revised Sewer Phasing/Service Areas (Section 3 of AWCMP Outline)
5. Proposed Non-Traditional Technologies (Section 4 of AWCMP Outline)
6. Adaptive Management Approach (Section 5 of AWCMP Outline)
7. Costs (Section 6 of AWCMP Outline)
8. DEP and CCC Comments regarding ACWMP Outline
9. Next Steps

AECOM
Orleans 2023 Amended Comprehensive Wastewater Management Plan (ACWMP)
Draft Annotated Outline
September 25, 2023
For Discussion at September 28 MassDEP/CCC Meeting

1.0 Executive Summary

This section will summarize the salient points of the sections that follow.

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

This section will provide background on the Town's comprehensive wastewater management planning process, including an evaluation of current and future wastewater needs, identification of wastewater management alternatives, and development of recommended strategies and an Adaptive Management Plan. It will briefly summarize that in 2010, a Comprehensive Wastewater Management Plan was prepared that proposed to meet state and federal mandates through an expansion of the municipal sewer system under an Adaptive Management Plan. Subsequently, in 2015, an updated Section 208 Plan was approved by Massachusetts Department of Environmental Protection (MassDEP) and U.S. Environmental Protection Agency (EPA), which included recommendations for improving water quality and identified potential alternative technologies to achieve improvements. Following this, a Consensus Agreement was developed to assess alternative strategies for managing wastewater and reducing nitrogen in the Rock Harbor, Nauset Marsh, and Pleasant Bay, watersheds. This Amended CWMP summarizes the results of actions and studies since 2010 and outlines the Town's currently proposed approach to wastewater management.

2.1 2010 CWMP/SEIR

This section will provide an overview of the 2010 CWMP and Massachusetts Environmental Policy Act (MEPA) approved Single Environmental Impact Report (SEIR). The 2010 CWMP/SEIR proposed a new centralized sewer system to reduce nitrogen loads to coastal bays and estuaries in Orleans. The municipal system would serve over one-half of developed properties in Orleans and cost an estimated $150 million over 15 to 20 years.

2.2 Cape Cod Commission 208 Plan Update Recommendations

In 2013, due to the impairment of water quality in coastal waters resulting from excess nitrogen, MassDEP directed the Cape Cod Commission to develop an update to the 1978 Water Quality Management Plan for the region in accordance with Section 208 of the federal Clean Water Act. The Cape Cod Commission 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 were considered by the Town of Orleans in their subsequent wastewater planning process.

2.3 2015 Consensus Agreement/Orleans Water Quality Advisory Panel (OWQAP)

This section will describe how 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 consisted of stakeholder representatives (Orleans Select Board Members and representatives of engaged citizen constituencies) and liaisons from key town boards and commissions, organizations, neighboring towns, and regional, state, and federal partners. The Consensus Plan included two general areas for sewers. The first area included approximately 270 parcels encompassing Downtown Orleans, which lies within the Town Cove subwatershed of Nauset Marsh watershed and partially within the Rock Harbor watershed. The second area included approximately 286 parcels within the Meetinghouse

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Pond subwatershed of the Pleasant Bay watershed. The OWQAP reviewed potential alternative planning scenarios to meet water quality standards that were presented at meetings and workshops. The Consensus Plan developed described a combination of Traditional and Non-Traditional technologies that meet the Massachusetts Estuaries Project load-reduction targets for nitrogen in each impaired waterbody. The OWQAP completed its work in 2017.

2.4 MEPA Notices of Project Change (NPCs)

This section will briefly summarize the 2018 and 2019 NPCs by describing the subject matter covered in each NPC and the Secretary's Determinations as summarized in the Certificates. This section will also state that the Certificates are provided as attachments, and that the comments received on each and the responses are summarized in Section 7.1.

2.5 Wastewater Management Advisory Committee (WMAC)

The Wastewater Management Advisory Committee (WMAC) was formed in 2022 to continue work on Orleans wastewater management. The members of this committee include members from Town Boards, Committees, and Commissions. The committee is charged with completing the following tasks:

- Review past documents to gain a working knowledge of relevant studies and reports key on decisions and project milestones that may have a bearing on wastewater management.
- Identify, complete, and submit the required CWMP amendments in a timely manner
- Develop an understanding of work completed on alternative wastewater technologies that were recommended in the 2015 Consensus Agreement and have been evaluated since that time
- Develop an understanding of regulatory requirements to preserve and protect marine and freshwater bodies within the Town
- Determine if further investigation is needed on alternatives
- Develop a decision-making process for weighing the relative value, costs, and benefits of alternative technologies compared to traditional sewers for each watershed
- As part of the decision-making process, include public outreach and feedback
- As part of the decision-making process, work with the Town Manager and Finance Director on the long-range capital planning schedule, taking into account the Town debt schedule in an effort to maintain a stable tax rate
- Provide quarterly updates to the Select Board on the recommended future sewer phases and/or permanent alternative technologies to meet MassDEP requirements for water quality restoration

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2.6 Amended CWMP

This section will provide a summary of the overall structure of the Amended CWMP, will explain that the ACWMP has been developed to update the Town's plans to meet nitrogen removal goals, and will give an overview of the Town's approach to tracking nitrogen removal by watershed, based on water use data, which informed the proposed combination of sewering, aquaculture, PRBs, and adaptive management to meet these goals. This section will include Wright-Pierce July 25, 2023 figure illustrating Orleans watershed boundaries and nitrogen removal needs.

3.0 Sewering Facilities Design

3.1 Disposal Site Investigations

This section will summarize the disposal site investigations, DEP approval of the Hydrogeologic Studies, and the DEP Groundwater Discharge Permit. The 2018 NPC regarding MEPA approval of the new groundwater discharge location will be referenced and summarized. Updated tables reflecting projected nitrogen loads to receiving waters will be provided based on wick discharge rates ranging from 50,000 to 500,000 gpd and nitrogen discharge concentrations of 5 mg/L and 10 mg/L.

3.2 Updated Sewer Service Areas and Phasing Plan

This section will provide the updated figure illustrating the 2023 sewer service areas as well as the proposed sewer phases and compare the anticipated range of nitrogen removal anticipated via sewering as compared to the nitrogen removal goals. The 2023 service areas correspond to the 2010 CWMP "Core Area" but extend the time period for completing sewer installation in these areas through 2067 due to multiple considerations, including the Town's need to address other financial needs and continuing studies on PRBs and nitrogen attenuation, as discussed in subsequent sections of the Amended CWMP. Updates on sewer phases completed/in progress follow in sections subsequent to this overall update section. This section will include a sewer service phasing chart and table summarizing projected nitrogen load reductions for a range of 4 to 4.5 mg/L nitrogen removal per water use record This section will also report on the Town's updated water meters, which allow for accurate tracking of water use data in 2022 and 2023, and future years. Water use records for 2022 and 2023 will be summarized, and the mean water use reported for planning purposes in regard to nitrogen removal estimates.

3.3 Phase 1 – New WWTP and Downtown Sewering

This section will summarize information regarding the new WWTP constructed and flows projected to flow to it based on the Phase 1 Downtown Sewering. Approximately 5,000 kilograms of nitrogen per year (kg N/year) are projected to be removed as a result of Phase 1. This section will also discuss the 2015 Downtown Build-Out analysis and the Amended Zoning Bylaws Article V. Section 14-31 – Apartment Development.

3.4 Phase 2 – Meetinghouse Pond Sewering

This section will summarize information regarding the construction of the Phase 2 Meetinghouse Pond collection area. This section will also mention the Fall 2023 Town Meeting article to approve expansion of Phase 2 to include Tides End Lane as an additional

step towards meeting the Town's requirements for nitrogen removal from the Pleasant Bay watershed. Given a favorable result at the Fall Town Meeting and favorable bidding for this modification to the existing Phase 2 construction contract, the Phase 2 Meetinghouse Pond area will include sewering on Tides End and Haywards Lanes. Approximately 2,000 kg N/year are projected to be removed as a result of Phase 2.

3.5 Future Wastewater Collection Phases

This section will discuss anticipated infrastructure components for future phases and associated impacts.

3.6 Municipal Areas Beyond Core Service Area

This section will discuss considerations for nitrogen reductions outside of the "Core Area" identified in the 2010 CWMP, including consideration of Non-Traditional Technologies such as Permeable Reactive Barriers (PRBs), pending future study; aquaculture; attenuation potential; and other adaptive management approaches, as discussed in subsequent sections

3.7 Tri-Town Transition

This section will summarize information regarding the decommissioning of the "Tri-Town" Facility and related septage receiving at the new WWTP.

4.0 Nitrogen Loading Reduction Via Non-Traditional Technologies

As recognized in the 2010 CWMP/SEIR and the Consensus Agreement, Non-Traditional nitrogen control strategies can reduce the volume of wastewater that requires treatment at wastewater treatment facilities and result in lower treatment costs for the Town. This section provides an overview of the types of Non-Traditional Technologies considered as part of the hybrid approach to wastewater management in Orleans. It also discusses the completed and ongoing demonstration projects implemented to test and confirm the effectiveness of specific technologies in select locations of the Town. The Consensus Agreement recommended three Non-Traditional 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. An additional innovative Non-Traditional Technology, a Nitrogen Reducing Biofilter (NRB), was also considered for implementation in Orleans. This section describes each of these NT tools, discusses the site selection process for demonstration projects for each Non-Traditional Technology, and describes the work plan associated with the demonstration projects.

4.1 Floating Constructed Wetlands

Floating Constructed Wetlands (FCWs) were one of the Non-Traditional technologies that were considered to reduce nitrogen loads to receiving waters. This section will summarize the process used to evaluate FCWs and the conclusion that this technology was not recommended for a demonstration project or further evaluation.

4.2 Aquaculture

Aquaculture was a second Non-Traditional technology considered to reduce nitrogen loads to receiving waters. This section will summarize the process used to evaluate potential

demonstration sites for aquaculture and the results of the ongoing Lonnie's Pond Aquaculture project. This section will state that the Town intends to continue with the aquaculture program currently underway at Lonnie's Pond based on their understanding that DEP has accepted this technology and that a nitrogen removal credit award is pending. Nitrogen removal from an aquaculture deployment of approximately 0.37 acre has ranged between approximately 51 and 64 kg N/year since 2018, resulting in an average removal of approximately 64 kg N/year. However, review has determined that there are no other cost-effective sites within the Town to implement aquaculture and therefore the Town does not intend to expand the program at this time.

This section will also note that the Town has conducted ground-breaking analysis of aquaculture so that this will be recognized as a standard practice in the future as it is a cost-effective and community-based approach that is complementary to other traditional approaches for nitrogen removal. The Town looks forward to transitioning to reduced monitoring and a standardized approach to compliance monitoring upon MassDEP approval of the aquaculture nitrogen removal credit. The inclusion of aquaculture at Lonnie's Pond in the Pleasant Bay Targeted Watershed Management plan will be summarized in this section. The 2019 NPC regarding MEPA approval of Non-Traditional Technologies will be referenced and summarized.

4.3 Permeable Reactive Barriers

Permeable Reactive Barriers (PRBs) are a third Non-Traditional technology that have been considered to reduce nitrogen loads to receiving waters. This section will summarize the process used to evaluate potential demonstration sites for PRBs, the Eldredge Park Demonstration Project, evaluation of other potential PRB sites screened for implementation, and four potential future PRB sites (Norseman, Duck Hole, Mayflower, and Lockwood) that require further evaluation to assess potential efficacy/feasibility. The 2019 NPC regarding MEPA approval of Non-Traditional Technologies will be referenced and summarized. This section will include maps illustrating the four sites proposed for further evaluation. The Town was appreciative of DEP's recognition of the value of PRBs through its inclusion of the Town of Orleans proposed PRB project on the 2022 State Revolving Fund Intended Use Plan (IUP); although the Town chose not to proceed with the PRB project at that time, they anticipate potentially returning to MassDEP to request additional funding consideration in the future.

4.4 Nitrogen Reducing Biofilters

Nitrogen Reducing Biofilters were a fourth Non-Traditional technology that was considered to reduce nitrogen loads to receiving waters. This section will summarize the process used to evaluate NRBs and the conclusion that this technology was not recommended for a demonstration project or further evaluation.

5.0 Adaptive Management Plan

An adaptive management approach to wastewater management planning in Orleans was proposed in order allow for ongoing evaluation, modification, and implementation of the proposed Non-Traditional Technologies as well as non-structural solutions to nitrogen loading. The 2010 CWMP/SEIR included an Adaptive Management Plan 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. This section

describes the baseline water quality data available and ongoing studies that may influence future decisions regarding wastewater management. This section will also summarize tasks completed or anticipated in regard to management of freshwater ponds in the Town of Orleans, monitoring of Namskaket Marsh for potential vegetation changes associated with the WWTP effluent discharge, stormwater management to reduce pollutants in receiving waters, and Town policies regarding fertilizer and herbicide applications. This section will also summarize Orleans' involvement with the Pleasant Bay Watershed Alliance and ongoing efforts associated with the existing Pleasant Bay Watershed Permit and its five-year renewal.

5.1 Recommended Technologies

This section will explain that although multiple Non-Traditional Technologies have been evaluated, the only two currently identified for long-term implementation are aquaculture and PRBs. In addition to continuation of the PRB at Eldredge Park, the use of PRBs is planned for additional investigation for four areas of Town (Norseman, Duck Hole, Mayflower, and Lockwood).

5.2 Growth

This section will explain that development growth within the Town of Orleans is difficult to predict and subject to a myriad of factors that cannot all be anticipated. Thus, the Adaptive Management Approach allows for course corrections in the future to address this uncertainty. Orleans has experienced a growth rate of approximately 5% based on actual growth rate of 3.9% over the past 20 years.

5.3 Pleasant Bay Alliance Watershed Permit

This section will describe collaborative efforts with the Pleasant Bay Watershed Alliance to address nitrogen loading to this receiving water body. The section will summarize the Pleasant Bay 21 seasons of water quality monitoring and the existing Watershed Permit. This section will refer to and summarize the compliance table included in the annual Pleasant Bay Alliance reports, provided by Mike Giggey of Wright -Pierce.

5.4 Town of Orleans Water Quality Monitoring Data

This section will summarize the results of the technical memorandum entitled Final Water Quality Monitoring and Modeling: Consolidation and Comparison of Baseline Monitoring Data Sets. This section will also explain that the Town has collected data throughout all receiving waters, including Nauset, and is currently undertaking an effort to organize and simplify the data to illustrate data trends that can be easily understood by the public. A scope of work for this effort is under development and anticipated to be implemented in spring 2024. The current Town dataset is not intended to support a TMDL but to illustrate trends and potentially identify areas requiring more focused monitoring in the future in support of a TMDL, as the Nauset and Rock Harbor estuaries currently lack TMDLs. The Nauset Harbor MEP Report utilized 2001 – 2004 water quality data obtained at 15 sampling stations. Upon receipt of the Nauset MEP report in 2012, the Towns reduced sampling to 3 sentinel stations. In 2016, Orleans and Eastham increased the number of sampling stations to 12 at the direction of University of Massachusetts (UMass) Dartmouth School of Marine Science and Technology (SMAST) staff to enable a future updating of the MEP model. That level of sampling has continued through the 2023 summer sampling season.

This section will also describe that future TMDLs would be anticipated to focus on the concentration of nitrogen in the water columns; however, the end goal of the TMDLs would be

habitat restoration, which can be affected by multiple factors. There are also additional factors other than nitrogen loading that can affect receiving waters, such as climate change. Therefore, tracking water quality is a useful tool to address future change.

5.5 Pochet Neck Nitrogen Attenuation Study

This section will summarize the UMass SMAST scope of work for the currently ongoing nitrogen attenuation study at Pochet Neck and note that the results of the study may be used to adjust the sewering approach for homes in the service area.

5.6 Namskaket Marsh Monitoring

This section will summarize the two years of monitoring that has taken place at Namskaket Marsh to evaluate existing plant communities and facilitate an assessment of any changes over time to address concerns that introduction of freshwater into this area may cause an increase in Phragmites growth in the marsh. Monitoring of Namskaket Marsh is complete.

5.7 Other Studies Completed between 2016 and 2017

This section will summarize the various studies and technical memoranda completed between approximately 2016 and 2017 to demonstrate the progress that has been made since the 2010 CWMP. Some of the information in these memoranda is now outdated/superseded, but the information developed will be summarized for inclusion in the Amended CWMP to provide a framework for the efforts the Town has taken to date to advance wastewater planning efforts. This section will include a discussion regarding the remediation of the landfill lagoons which had been a substantial source of nitrogen loading to the Town Cove watershed.

5.8 Freshwater Ponds

This section will discuss the watershed management plans created to target phosphorous reductions for Crystal Lake, Uncle Harvey's Pond, Pilgrim Lake, and Bakers Pond. Tributary areas to Boland Pond are currently sewered, which is expected to substantially improve water quality in Boland Pond. The text will explain that Uncle Harvey's Pond received alum treatment in 2021 and that all contributing upgradient parcels to Uncle Harvey's Pond have been included in Phase 2 Meetinghouse Pond. The text will explain that Pilgrim Lake and Crystal Lake are included in Phase 3. In regard to Cedar Pond, this section will explain that parcels were included in Downtown Phase 1, and that the removal and relocation of the Eversource power lines was a key component of reducing nutrients, as illustrated by representative photos. The text will also explain that Pilgrim Lake experienced a cyanobacteria bloom in summer 2023. As a result, alum treatment is currently under consideration for Pilgrim Lake. Alum treatment was recommended for Crystal Lake in the management plan developed by Marine and Freshwater Quality Committee. This section will acknowledge that improved pesticide and fertilizer practices in the contributing drainage areas to freshwater ponds can assist improving water quality as discussed further below in Section 5.9.

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5.9 Integrating Stormwater and Fertilizer Management Programs

This section will summarize the Town's current compliance with the EPA Massachusetts Separate Storm Sewer System (MS4) requirements for stormwater, and the Town's policies for fertilizer/herbicide/pesticide use as well as ongoing Town efforts to encourage responsible use of fertilizers. This section will also reference and summarize the proposed Pesticide Reduction By-law, the Town's 2012 Policy for fertilizer and pesticide use, and the existing Town fertilizer By-law. Updated fertilizer and pesticide bylaws will require home rule petition to the State Legislature. This section will state that the Town recognizes the need for and value of public education, and toward that end has literature available at the Town Hall and on the Town website regarding best practices for fertilizer, pesticide, and herbicide use. This section will also describe that the Town has been implementing stormwater improvements throughout Town, as well as integrating stormwater improvements into sewering and stormwater projects. This section will describe stormwater management BMPs already implemented or designed as part of Phases 1 and 2 of the wastewater master plan.

5.6 Regional Coordination with Eastham and Brewster

This section will summarize the Eastham Memorandum of Understanding (MOU) and include it as an attachment and will explain that the Town is beginning coordination with Brewster, which is just starting their water quality management committee in addition to being part of the PBA. The Town of Orleans is currently exploring the potential of nitrogen trading options with Brewster in regard to nitrogen contributions to shared receiving waters. This approach is identified as a measure in the Pleasant Bay Watershed Permit Targeted Watershed Management Plan; the table identifying the potential for nitrogen trading options will be referenced and included in this section.

6.0 Project Costs

MassDEP CWMP guidance is that a cost effectiveness analysis should be performed on all alternatives advanced for detailed analysis. The alternatives that are proposed for detailed analysis in Orleans include sewering, PRBs, and aquaculture. The 2010 CWMP included a cost analysis of sewering, which will be summarized in this section. In addition, the capital and operation and maintenance (O&M) costs associated with sewer phases 1 (Downtown) and 2 (Meetinghouse Pond) will be reported. Cost analysis of aquaculture and PRBs, including cost/kg N removal, were evaluated during work completed as part of the OWQAP. The PRB and aquaculture costs previously evaluated included capital costs, operation and maintenance costs, and replacement costs. These costs will be summarized in this section.

This section will also state that the Town is cognizant of several necessary projects within the municipality that will require substantial capital costs, which will be considered, along with the proposed phased sewering, in a 20-year capital improvement plan currently under development. Due to the need to balance long-term capital costs associated with other municipal needs such as library, fire and rescue, affordable housing, community center, and others, there is a new regional high school underway and there is a potential need for a new elementary school, the Town has developed a phased approach to sewer implementation, which proposes a new construction phase approximately every three years. The subsequent phase will begin design once the previous phase starts construction. This section will also state that the Town has been able to take advantage of multiple funding sources and subsidies – such as State Revolving Fund (SRF) and the Cape and Islands Water Protection

Fund – so as to optimize such funding and decrease financial burden on municipal taxpayers. The Town has worked diligently to gain confirmation from MassDEP that their municipal land use policies qualify wastewater projects for 0% SRF loans. The Town has also established a wastewater stabilization fund dedicated to funding wastewater projects, and in May 2019 passed a resolution that directs revenue from hotel/motel and short-term rental fees into the wastewater stabilization fund. To date, the funding in the wastewater stabilization fund has averaged $1.8 million per year, which has provided the Town with a stable funding source to help support the implementation of wastewater projects.

7.0 Regulatory Review and Coordination

This section will summarize comments received on the 2010 CWMP/SEIR, the 2018 MEPA NPC regarding the effluent discharge location, and the 2019 NPC regarding consideration of Non-Traditional Technologies. This section of the ACWMP will provide responses to these previously received comments as well as a summary of permitting requirements associated with the implementation of the ACWMP and a Draft Section 61 Finding in accordance with MEPA requirements.

7.1 Response to 2010 CWMP/SEIR Comments and 2018 and 2019 NPC Comments

Past comments received will be summarized in tables, accompanied by a response, and reference to related section of the Amended CWMP, where applicable.

7.2 Cape Cod Commission (CCC)

This section will discuss the CCC Developments of Regional Impact (DRI) approval of the 2010 CWMP and conditions included therein. Many of these conditions require communication with the CCC on on-going efforts to design, plan and implement the CWMP and the amendments described in the current document. The CCC requested to be involved in the Adaptive Management Plan process. These conditions have been met, as the CCC was an active participant in the OWQAP between 2015 and 2017. In addition, the CCC was a participant at a pre-filing meeting scheduled for September 28, 2023 with DEP for a presentation regarding the contents of this Amended CWMP.

7.3 MassDEP

This section will describe efforts to coordinate with DEP during the preparation of the Amended CWMP, including DEP's involvement in the OWQAP, coordination regarding the construction of the WWTP and groundwater disposal, request for the aquaculture nitrogen removal credit, and the meeting held on September 28, 2023 for Orleans presentation of the contents of this Amended CWMP.

7.4 Executive Order 569: Evaluating an Integrated Climate Change Strategy

This section will include text to describe compliance of the Amended CWMP with EO 569, to address MEPA's request in the 2019 NPC Certificate.

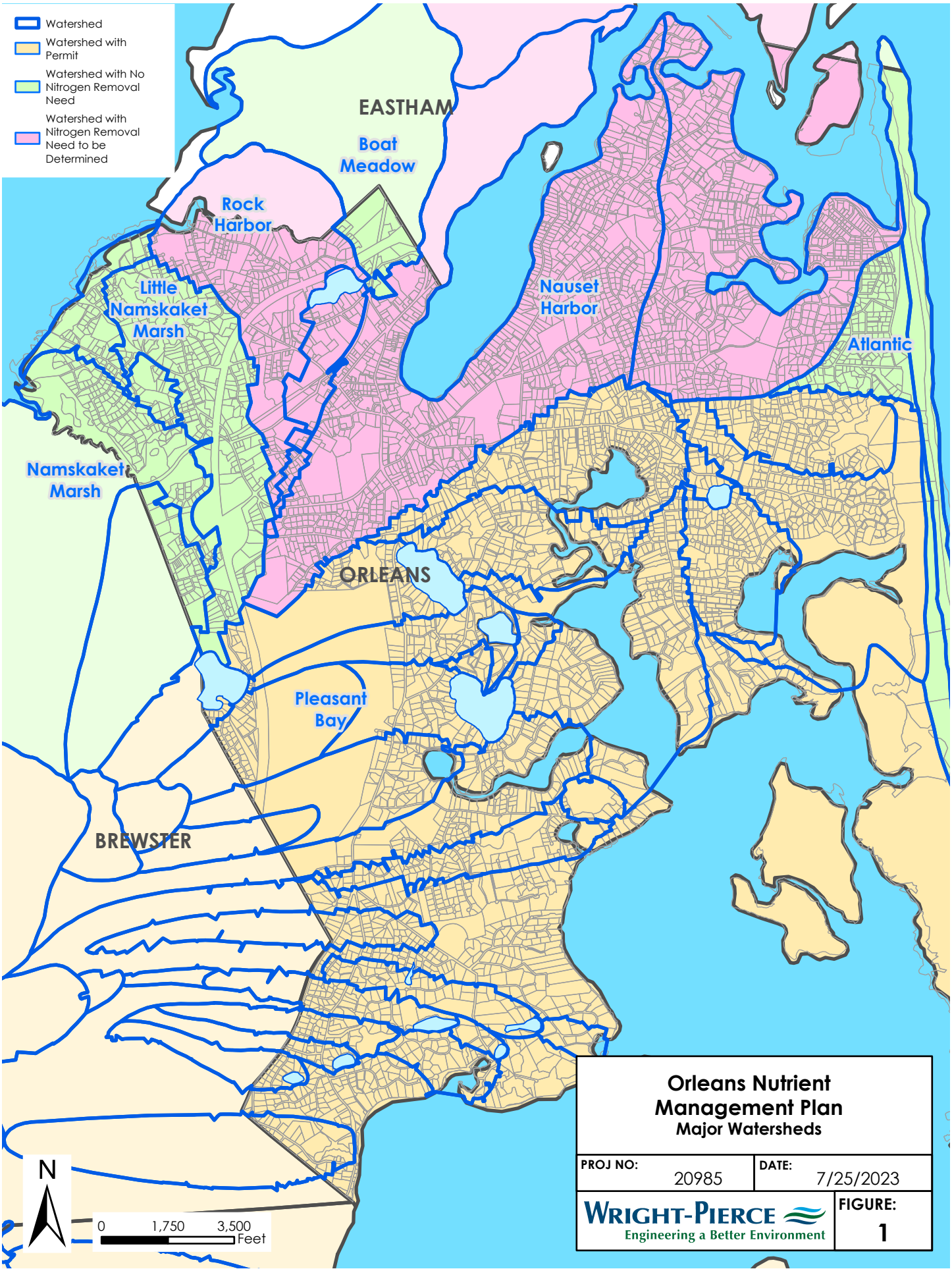
7.5 Section 61 Findings

This section will include a draft Section Finding in accordance with MEPA requirements.

8.0 References

9.0 Glossary

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Orleans Nutrient Management Plan
Major Watersheds

PROJ NO:	DATE:
20985	7/25/2023

WRIGHT-PIERCE
Engineering a Better Environment

FIGURE: 1

CLM W:\GIS_Development\Projects\MA\Orleans\20985_NutrientMgmt\MXDs\Orleans_NutrientMgmt_Figures.aprx

Town of Orleans, MA

APPROVED AND PROPOSED SERVICE AREAS WITH WATERSHEDS

Legend

- Wastewater Treatment Facility
- Aquifer Recharge
- Watershed Boundary
- Arey's Pond
- Downtown
- Eldredge Park Way 1
- Eldredge Park Way 2
- Lakes and Ponds
- Meetinghouse Pond
- Meetinghouse Pond - 2
- Mill Pond / Pochet North
- Little Namskaket
- Pochet East
- Pochet West
- Rock Harbor
- South Orleans - A
- South Orleans - B
- South Orleans - C
- South Orleans - D
- South Orleans - E
- South Orleans - F
- Tonset
- Town Cove South

Date: 9/26/2023

AECOM

0 960 1,920 Feet

CAPE COD BAY

EASTHAM

Rock Harbor (16)

Downtown (1)

Little Namskaket (14)

Eldredge Park Way 1 (14)

Eldredge Park Way 2 (15)

Lakes and Pond (3)

Arey's Pond (3)

South Orleans - A (4)

BREWSTER

South Orleans - E (5)

TOWN COVE

Town Cove South (12)

Tonset (13)

Mill Pond / Pochet North (11)

Meetinghouse Pond (2)

Meetinghouse Pond 2 (2)

Pochet East (10)

Pochet West (9)

South Orleans - B (6)

South Orleans - C (8)

South Orleans - D (8)

South Orleans - F (7)

PLEASANT BAY

C:\Work\60652634ORL\Maps\Planning_2023_FutureBoundaries\Watersheds_v4_11x17.mxd

ATTACHMENT F

MASSDEP APPROVALS FOR LOTS HOLLOW RD, ROUTE 6 CLOVER LEAF, AND BEACH RD HYDROGEOLOGIC INVESTIGATIONS AND THE OVERLAND WAY WWTF EFFLUENT DISCHARGE PERMIT

MassDEP
Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Matthew A. Beaton
Secretary

Martin Suuberg
Commissioner

February 17, 2017

Mr. John Kelly
Town Administrator
Orleans Town Hall
19 School Road
Orleans, MA 02653

RE: ORLEANS – 223 Beach Road,
BRP WP 83 Approval
of Hydrogeologic Evaluation Report,
Transmittal Number X271059

Dear Mr. Kelly:

The Massachusetts Department of Environmental Protection (MassDEP) has completed its review of the hydrogeologic evaluation report titled "HYDROGEOLOGIC EVALUATION PROPOSED EFFLUENT DISPOSAL FACILITIES 223 BEACH ROAD TOWN OF ORLEANS, MASSACHUSETTS", dated June 23, 2016 and submitted on your behalf by AECOM. The report summarizes the results of a hydrogeologic evaluation conducted by AECOM to support a future Groundwater Discharge Permit Application for a proposed effluent discharge at 223 Beach Road in Orleans, Massachusetts. The evaluation was conducted in accordance with the scope-of-work submitted by AECOM on November 30, 2016 and approved by MassDEP on January 19, 2016. Notice of the availability of the scope-of-work was published in the Environmental Monitor on December 23, 2015.

The evaluated discharge location is the site of five joined parcels, about 8.65 acres, owned by the Town of Orleans. This site was chosen because the groundwater flow discharges to the Atlantic Ocean as opposed to an estuary which could be adversely impacted by the nitrogen in the proposed treatment plant effluent. The site is not located within any Zone II wellhead protection areas.

Soil tests and borings performed within the footprint of the proposed infiltration beds encountered mostly medium to fine sands and silty sand in some areas. There were a total of seven test holes and four soil borings drilled. Four monitoring wells were also installed. A percolation test was carried out on TP-1 in the C2 layer characterized as medium sand, and it was assumed to be representative the C layer in TP-2, the C2 layer in TP-3, the C1 and C3 layers in TP-4, the C1 and C3 layers in TP-5, the C2 layer in TP-6, and the C1 and C2 layers in TP-7. The result showed a percolation rate of less than 2 minutes per inch.

The proposed infiltration beds were evaluated at a design flow of 200,000 gallons per day (gpd). Soil evaluation and percolation testing of the proposed site supports a loading rate of 2.5 gpd/square foot using leaching trenches. The area required for the discharge is 140,000 square feet as proposed.

Groundwater was encountered in the monitoring wells at an average depth of approximately 40 feet. The average hydraulic conductivity was determined based on grain size analysis (189 ft/day) and from slug tests (236 ft/day). The seasonal high groundwater level was estimated by collecting water level information from USGS reference wells, which although over 8000 feet from the Beach Road site, share the same hydrogeologic setting. Groundwater contours were plotted by measuring water level from the four monitoring wells and converting them to elevations in mean sea level. This was used to determine the direction of groundwater flow which was due east towards the Atlantic Ocean.

AECOM updated a USGS model (Monomoy Lens) to be more representative of the Beach Road site. In order to show that the updated model was similar to the original USGS model and would give adequate prediction of the different effluent scenarios that were explored, both models were run to check for groundwater elevation at different points on the site. Similar results were obtained for both runs. The results of the simulation showed that there would be no impacts with respect to groundwater mounding. At the highest proposed flow volume of 500,000 gpd, the simulation showed that a mound of only about 3.5 feet is expected. The estimated high water level elevation was 1.54 feet. These elevations provide more than the required four feet of unsaturated separation between the top of the mounded seasonal high water table and the base of the proposed disposal beds.

The results of the groundwater mounding were verified by The Department using AQTESOLV groundwater mounding calculator by inputting the highest proposed loading rate of 500,000 gpd, the area of discharge area mentioned in the report and all other necessary parameters from the results in the hydrogeologic report. A groundwater mounding of about 4.5 feet was predicted from this process. Based on the results shown and verification using the calculator, mounding is not expected to be a concern at the site even at high discharge volumes of up to 500,00 gpd. The results of the simulation carried out by AECOM also showed the possibility of particles traveling into Pochet Neck at loading rates greater than 200,000 gpd.

On June 23, 2016, AECOM submitted a revised Groundwater Monitoring Plan to MassDEP that outlines procedures for the long-term monitoring of groundwater quality in the vicinity of the proposed soil absorption system. The plan proposes a monitoring well network that consists of monitoring wells; MW-1, MW-2, MW-3 and MW-4 all existing and MW-5, MW-6 and MW-7 to be installed.

Pursuant to 314 CMR 5.09 (1) (f), MassDEP hereby approves the hydrogeologic report submitted by AECOM and authorizes the applicant to apply for an Individual Groundwater Discharge Permit (BRPWP 79) subject to the following conditions:

1. The design flow of the proposed groundwater discharge shall not exceed 200,000 gallons per day.

2. The loading rate to the infiltration beds shall not be greater than 2.5 gpd/square foot if leaching trenches are utilized.

3. The proposed infiltration beds shall not be constructed until a Groundwater Discharge Permit has been obtained from MassDEP.

4. The proposed infiltration beds shall be constructed within the footprint indicated on Figure 5, "PROPOSED GROUNDWATER DISCHARGE AREA" found in the hydrogeologic report. .

5. There is a private well which might be affected by the discharge at the site and will need to connect to the Town of Orleans public water supply or be monitored on an annual basis for adverse impacts.

6. Some of the silty soil encountered close to the surface during test pit excavation will be removed and replaced with appropriate fill material.

   The site is suitable for accepting effluent based on the results at loading rates less than 200,000 gpd.

7. MassDEP approves the monitoring well locations proposed in the Groundwater Monitoring Plan. Upgradient and downgradient wells must be specified. The proposed well locations and approved monitoring plan will be referenced in the Groundwater Discharge Permit when issued. MassDEP recognizes that proposed locations are somewhat dependent upon final site development (e.g. building and road placement) and may require modification; however, changes must be submitted to this office for approval prior to well installation. Final monitoring wells must be installed and sampled for all groundwater quality parameters listed in the issued permit no later than 90 days prior to startup of the wastewater treatment plant and discharge to the infiltration beds.

8. An Initial Groundwater Monitoring Well and Groundwater Quality Report must be submitted to this office prior to any discharge of wastewater. This report must include:

   a. a final surveyed site plan with location of the infiltration beds, all monitoring wells and all appropriate elevation data,

   b. boring logs and well construction details for all monitoring wells, and

   c. the analytical results of the groundwater samples collected from the final groundwater monitoring wells. These results will establish the baseline groundwater quality for the site.

Please be advised that this approval **is not** a Groundwater Discharge Permit. It does, however, authorize the project proponent to submit an Individual Groundwater Discharge Permit application for the discharge described at the evaluated location. MassDEP requires that the Individual Groundwater Discharge Permit application (BRPWP 79) be accompanied by a MassDEP Transmittal form and include all required supporting documentation. Included in the supporting documentation shall be a certification from a Massachusetts Registered Professional Engineer that the approved Hydrogeologic Evaluation Report has been reviewed and accurately reflects site conditions as of the date of permit application. Information on any changes noted during the review shall be included in the Engineering Report that accompanies the application. Please be advised, the submittal of plans and specifications may be required at any time during the review of the permit application.

If you have questions regarding the comments and conditions of this approval, please contact Kermit Studley of this office at (508) 946-2803.

Sincerely,

Brian A. Dudley
Bureau of Water Resources

cc: Mark Owen, PG
AECOM,
9 Jonathan Bourne Drive,
Pocasset, MA 02559

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection
Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Matthew A. Beaton
Secretary

Martin Suuberg
Commissioner

May 9, 2019

Mr. Thomas E. Parece, P.E.
AECOM Technical Services, Inc.
9 Jonathan Bourne Drive
Pocasset, Massachusetts 02559

City/Town: Orleans
RE: Hydrogeologic Report
Program Identifier: BRP WP 83
Transmittal No.: X277248
Facility Name:
TOWN OF ORLEANS, MASSACHUSETTS
Water Quality and Wastewater Planning
Hydrogeologic Evaluation
Proposed Groundwater Discharge
32 and 43 Lots Hollow Road , (WICK LOADING TEST)
Authorization Type: Approval

Dear Mr. Parece:

The Massachusetts Department of Environmental Protection (MassDEP) has completed its review of the hydrogeologic evaluation report titled "Groundwater Discharge Hydrogeologic Evaluation 32 and 43 Lots Hollow Road", ("the Report") dated August 2, 2018. The report summarizes the results of a hydrogeologic evaluation conducted by AECOM to support a future Groundwater Discharge Permit Application for a proposed effluent discharge at 32 Lots Hollow Rd. AECOM conducted the evaluation in accordance with the scope-of-work submitted on January 12, 2018. On January 29, 2018, Mr. Mark Owen (AECOM), Mr. Brian Dudley (MassDEP) and Mr. Stephen Hallem (MassDEP) visited the site to discuss site conditions and the loading test proposal. This letter documents the approach used to evaluate the 32 Lots Hollow site for a wick groundwater discharge for treated effluent generated from the proposed downtown area wastewater treatment facility (WWTF) in Orleans, Massachusetts.

The Town of Orleans has selected 32 Lots Hollow as the primary discharge location and is seeking MassDEP approval to discharge 500,000 gpd at the site. The request to discharge WWTF effluent at the site will be included as part of the Groundwater Discharge Permit application. The Report also evaluated 43 Lots Hollow Road as a secondary site, and field investigations indicate similar lithologic and hydraulic conditions to 32 Lots Hollow Road.

This information is available in alternate format. Contact Michelle Waters-Ekanem, Director of Diversity/Civil Rights at 617-292-5751.
TTY# MassRelay Service 1-800-439-2370
MassDEP Website: www.mass.gov/dep
Printed on Recycled Paper

All areas appear to have sufficient separation of the mounded water table from the bottom of the system and will be able to accept the specified flow.

Pursuant to 314 CMR 5.09 (1) (f), MassDEP hereby approves the hydrogeologic report submitted by AECOM and authorizes the applicant to apply for an Individual Groundwater Discharge Permit (BRPWP 79) subject to the following conditions:

1. The design flow of the proposed groundwater discharge shall not exceed 500,000 gallons per day at either 32 or 43 Lots Hollow Road.

2. The proposed wicks shall not be constructed until a Groundwater Discharge Permit has been obtained from MassDEP.

3. The proposed wicks shall be constructed within the footprint indicated on Figure 4, "SITE PLAN" found in the hydrogeologic report.

4. There are private wells which might be affected by the discharge at the site and will need to connect to the Town of Orleans public water supply or be monitored on an annual basis for adverse impacts.

5. There is possible impact of mounding on the marshes; therefore, monitoring of the species present is recommended prior to discharge to document any potential changes during discharge commencement.

6. MassDEP approves the monitoring well locations proposed in the Groundwater Monitoring Plan. Upgradient and downgradient wells must be specified. The proposed well locations and approved monitoring plan will be referenced in the Groundwater Discharge Permit when issued. MassDEP recognizes that proposed locations are somewhat dependent upon final site development (e.g. building and road placement) and may require modification; however, changes must be submitted to this office for approval prior to well installation. Final monitoring wells must be installed and sampled for all groundwater quality parameters listed in the issued permit no later than 90 days prior to startup of the wastewater treatment plant and discharge to the infiltration beds.

7. An Initial Groundwater Monitoring Well and Groundwater Quality Report must be submitted to this office prior to any discharge of wastewater. This report must include:

    a. a final surveyed site plan with location of the infiltration beds, all monitoring wells and all appropriate elevation data,

    b. boring logs and well construction details for all monitoring wells, and

    c. the analytical results of the groundwater samples collected from the final groundwater monitoring wells. These results will establish the baseline groundwater quality for the site.

Please be advised that this approval **is not** a Groundwater Discharge Permit. It does, however, authorize the project proponent to submit an Individual Groundwater Discharge Permit application for the discharge described at the evaluated location. MassDEP requires that the Individual Groundwater Discharge Permit application (BRPWP 79) be accompanied by a MassDEP Transmittal form and include all required supporting documentation. Included in the supporting

documentation shall be a certification from a Massachusetts Registered Professional Engineer that the approved Hydrogeologic Evaluation Report has been reviewed and accurately reflects site conditions as of the date of permit application. Information on any changes noted during the review shall be included in the Engineering Report that accompanies the application. Please be advised, the submittal of plans and specifications may be required at any time during the review of the permit application.

If you have questions regarding the comments and conditions of this approval, please contact Steve Hallem at (617) 292-5681 or Stephen.hallem@state.ma.us .

Sincerely,

Brian Dudley, Section Chief
Wastewater Management – Cape and Islands

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

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Secretary

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Commissioner

May 10, 2019

Mr. Thomas E. Parece, P.E.
AECOM Technical Services, Inc.
250 Apollo Drive
Chelmsford, Massachusetts 01824

City/Town: Orleans
RE: Hydrogeologic Report
Program Identifier: BRP WP 83
Transmittal No.: X277248
Facility Name: GROUNDWATER DISCHARGE, HYDROGEOLOGIC EVALUATION, ROUTE 6 (EXIT 12) SITE TOWN OF ORLEANS, MASSACHUSETTS (WICK LOADING TEST)
Authorization Type: Approval

Dear Mr. Parece:

The Massachusetts Department of Environmental Protection (MassDEP) has completed its review of the hydrogeologic evaluation report titled "GROUNDWATER DISCHARGE HYDROGEOLOGIC EVALUATION, ROUTE 6 (EXIT 12) SITE, TOWN OF ORLEANS, MASSACHUSETTS, WICK LOADING TEST", ("the Report") dated August 2, 2018. The report summarizes the results of a hydrogeologic evaluation conducted by AECOM to support a future Groundwater Discharge Permit Application for a proposed effluent discharge near Exit 12 on Route 6. AECOM conducted the evaluation in accordance with the scope-of-work previously submitted.

The Hydrogeologic Evaluation updates the existing Hydrogeologic Evaluation titled "HYDROGEOLOGIC EVALUATION ROUTE 6 (EXIT 12) CLOVERLEAF SITE TOWN OF ORLEANS, MASSACHUSETTS" and submitted to MassDEP in October 2017. On February 2, 2018, MassDEP approved the hydrogeologic evaluation subject to several conditions. Two of the conditions being that:

(a) Design flow of the proposed groundwater discharge shall not exceed 145,000 gallons per day; and

(b) Loading rate to the infiltration beds shall not be greater than the maximum allowed under present Department Guidelines. If wicks are proposed and the preferred alternative, further testing will be required prior to approval of their installation.

On April 20, 2018, a proposal to perform a wick loading test at Route 6 (Exit 12) Site was submitted to MassDEP for review. Prior to submitting the proposal, Mr. Mark Owen (AECOM), Mr. Brian Dudley (MassDEP) and Mr. Stephen Hallem (MassDEP) visited the site on January 29, 2018 to discuss site conditions and the loading test proposal.

This letter documents the approach used to evaluate the Route 6 (Exit 12) site, shown in Figure 1 of the Report, for a wick groundwater discharge for treated effluent generated from the proposed Downtown Area wastewater treatment facility (WWTF) in Orleans Massachusetts. Copies of MassDEP's letter approving the hydrogeologic evaluation, and the wick loading test proposal are provided in Appendix A of the Report.

This letter includes the following:

- Description of the steps taken to evaluate the site for a wick groundwater discharge;
- Summary of field investigations conducted at the Route 6 (Exit 12) site;
- Evaluation of the loading test results; and
- Preliminary wick design and discharge capacity for the Route 6 (Exit 12) site.

A wick loading test was performed to evaluate the site for the use of wicks as a groundwater discharge method for effluent from the proposed Downtown Area WWTF. The results of the wick loading test do not change the findings and conclusions of the October 2017 Hydrogeologic Evaluation and therefore this document should be considered an addendum to the original report.

The wick sites appear to have sufficient separation of the mounded water table from the bottom of the system and will be able to accept the specified flow.

Pursuant to 314 CMR 5.09 (1) (f), MassDEP hereby approves the hydrogeologic report submitted by AECOM and authorizes the applicant to apply for an Individual Groundwater Discharge Permit (BRPWP 79) subject to the following conditions:

1. The design flow of the proposed groundwater discharge shall not exceed 350,000 gallons per day.

2. The proposed wicks shall not be constructed until a Groundwater Discharge Permit has been obtained from MassDEP.

3. The proposed wicks shall be constructed within the footprint indicated on Figure 5, found in the Report.

4. There are private wells which might be affected by the discharge at the site and will need to connect to the Town of Orleans public water supply or be monitored on an annual basis for adverse impacts.

5. There is possible impact of mounding on the marshes; therefore, monitoring of the species present is recommended prior to discharge to document any potential changes during discharge commencement.

6. MassDEP approves the monitoring well locations proposed in the Groundwater Monitoring Plan. Upgradient and downgradient wells must be specified. The proposed well locations and approved monitoring plan will be referenced in the Groundwater Discharge Permit when issued. MassDEP recognizes that proposed locations are somewhat dependent upon final site development (e.g. building and road placement) and may require modification; however, changes must be submitted to this office for approval prior to well installation. Final monitoring wells must be installed and sampled for all groundwater quality parameters listed in the issued permit no later than 90 days prior to startup of the wastewater treatment plant and discharge to the infiltration beds.

7. An Initial Groundwater Monitoring Well and Groundwater Quality Report must be submitted to this office prior to any discharge of wastewater. This report must include:

    a. a final surveyed site plan with location of the wick wells, all monitoring wells and all appropriate elevation data,

    b. boring logs and well construction details for all monitoring wells, and

    c. the analytical results of the groundwater samples collected from the final groundwater monitoring wells. These results will establish the baseline groundwater quality for the site.

Please be advised that this approval **is not** a Groundwater Discharge Permit. It does, however, authorize the project proponent to submit an Individual Groundwater Discharge Permit application for the discharge described at the evaluated location. MassDEP requires that the Individual Groundwater Discharge Permit application (BRPWP 79) be accompanied by a MassDEP Transmittal form and include all required supporting documentation. Included in the supporting documentation shall be a certification from a Massachusetts Registered Professional Engineer that the approved Hydrogeologic Evaluation Report has been reviewed and accurately reflects site conditions as of the date of permit application. Information on any changes noted during the review shall be included in the Engineering Report that accompanies the application. Please be advised, the submittal of plans and specifications may be required at any time during the review of the permit application.

If you have questions regarding the comments and conditions of this approval, please contact Steve Hallem at (617) 292-5681 or Stephen.hallem@state.ma.us .

Sincerely,

Brian Dudley, Section Chief
Wastewater Management – Cape and Islands

ecc: Mr. John Kelly, Town Administrator
19 School Road
Orleans, MA 02653
jkelly@town.orleans.ma.us

Mr. Ian Catlow
Tighe and Bond, Inc.
446 Main Street
Worcester, MA
ibcatlow@tighebond.com

Mr. Mark Owen
AECOM
9 Jonathon Bourne Drive
Pocasset, MA 02559
mark.owen@aecom.com

DEP/Boston
Attn: Stephen Hallem

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Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

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Martin Suuberg
Commissioner

March 31, 2020

Mr. John Kelly, Town Administrator
Town of Orleans
19 School Road
Orleans, Massachusetts 02653

RE: ORLEANS – Final Individual Groundwater Discharge Permit, Town of Orleans Wastewater Treatment Facility, 29 Overland Way, Orleans Massachusetts and 32 and 43 Lots Hollow Road
Transmittal No. X282490
Groundwater Discharge Permit No.: 993-0

Dear Mr. Kelly:

In response to your application for a permit to discharge into the ground treated effluent from the proposed Town of Orleans Wastewater Treatment Facility and after due public notice, I hereby issue the attached final permit.

Since no comments objecting to the issuance of the permit were received by the Department during the public comment period, in accordance with 314 CMR 2.08, the permit becomes effective at issuance.

Parties aggrieved by the issuance of this permit are hereby advised of their right to request an Adjudicatory Hearing under the provisions of Chapter 30A of the Massachusetts General Laws and 314 CMR 1.00, Rules for the Conduct of Adjudicatory Proceedings. Unless the person requesting the adjudicatory hearing requests and is granted a stay of the terms and conditions of this permit, the permit shall remain fully effective.

Should you have any questions regarding this matter, please contact me at (508)946-2814 or at brian.dudley@mass.gov.

Very truly yours,

Gerard M.R. Martin for

Brian A. Dudley, Section Chief
Wastewater Management – Cape and Islands

Enclosures (Permit, Fact Sheet)

This information is available in alternate format. Contact Michelle Waters-Ekanem, Director of Diversity/Civil Rights at 617-292-5751.
TTY# MassRelay Service 1-800-439-2370
MassDEP Website: www.mass.gov/dep

Printed on Recycled Paper

ecc: Mr. Robert Canning, Health Agent
Board of Health
19 School Road
Orleans, MA 02653
Enclosures (Permit, Fact Sheet)

Mr. Tom Parece
AECOM Technical Services Incorporated
9 Jonathan Bourne Drive
Pocasset, MA 02559
Enclosures (Permit, Fact Sheet)

DEP/BWR/Wastewater Management Program/Boston
Attn: Linda Barba
Julianne Ture
Enclosures (Permit, Fact Sheet)

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection
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Individual Groundwater Discharge Permit
Fact Sheet

I. APPLICANT, FACILITY INFORMATION, and DISCHARGE LOCATION

Name and Address of Applicant: Town of Orleans, 19 School Road, Orleans, Massachusetts 02653

Name and Address of Facility where discharge occurs: Wastewater treatment at 29 Overland Way, Orleans, Massachusetts with discharges at 32 and 43 Lots Hollow Road, Orleans, Massachusetts.

Discharge Information:

Groundwater Discharge Permit Number: 993-0

The Groundwater Discharge Permit will allow the applicant to discharge 228,900 gallons per day (annual average) with a maximum of 595,100 gallons per day for Phase 1 and 350,000 gallons per day (annual average) with a maximum of 883,800 gallons per day for Phase 2 of treated sanitary wastewater from a municipal wastewater treatment facility to groundwaters of the Commonwealth.

The discharge sites are not in a Zone II or Interim Wellhead Protection Area of any public drinking water supply.

II. LIMITATIONS AND CONDITIONS

Discharge permit limitations are as listed in the ground water permit and are in conformance with 314 CMR 5.00, the Groundwater Discharge Permit Program.

This information is available in alternate format. Contact Michelle Waters-Ekanem, Director of Diversity/Civil Rights at 617-292-5751.
TTY# MassRelay Service 1-800-439-2370
MassDEP Website: www.mass.gov/dep
Printed on Recycled Paper

III. PERMIT BASIS AND EXPLANATION OF EFFLUENT LIMITATIONS

An Individual Groundwater Discharge permit is required for this discharge in accordance with the Massachusetts Clean Water Act, M.G.L. c. 21, s. 26-53 and 314 CMR 5.03.

Effluent limitations are based upon the location of the discharge, the level of treatment, consideration of human health protection criteria and protection of the groundwaters of the Commonwealth.

The discharge will be via wicks located at 32 Lots Hollow Road. 43 Lots Hollow Road will serve as a backup site.

IV. COMMENT PERIOD, HEARING REQUESTS, AND PROCEDURES FOR FINAL DECISIONS

The public comment period for this permit is thirty (30) days following public notice in *The Environmental Monitor*. The public notice for this Individual Groundwater Discharge Permit occurred on February 10, 2020

Requests for an adjudicatory hearing must be submitted within thirty (30) days of the issuance/denial of the permit, by any person who is aggrieved by such issuance/denial.

A final decision on the issuance/denial of this permit will be made after the public notice period, and review of any comments received during this period.

V. STATE CONTACT INFORMATION

Additional information concerning the draft permit may be obtained between the hours of 9:00 a.m. and 5:00 p.m. Monday through Friday excluding holidays, from:

Gerard M.R. Martin

March 31, 2020

for: Brian A. Dudley, Section Chief
Wastewater Management Program – Cape and Islands

DATE

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection
Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

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Secretary

Martin Suuberg
Commissioner

INDIVIDUAL GROUNDWATER DISCHARGE PERMIT

Name and Address of Applicant: Town of Orleans, 19 School Road, Orleans, Massachusetts 02653

Date of Application: August 29, 2019
Application/Permit No. 993-0

Date of Issuance: March 31, 2020
Date of Expiration: March 31, 2025

Effective Date: March 31, 2020

AUTHORITY FOR ISSUANCE

Pursuant to authority granted by Chapter 21, Sections 26-53 of the Massachusetts General Laws, as amended, 314 CMR 2.00, and 314 CMR 5.00, the Massachusetts Department of Environmental Protection (the Department or MassDEP) hereby issues the following permit to: **Town of Orleans** (hereinafter called "the permittee") authorizing discharges to the ground from the wastewater treatment facility located at **Town of Orleans Wastewater Treatment Facility, 29 Overland Way, Orleans Massachusetts** with effluent recharge located at **32 and 43 Lots Hollow Road, Orleans, Massachusetts** such authorization being expressly conditional on compliance by the permittee with all terms and conditions of the permit hereinafter set forth.

Gerard M.R. Martin
FOR: Brian A. Dudley, Section Chief
Wastewater Management – Cape and Islands

March 31, 2020
Date

This Information is available in alternate format. Contact Michelle Waters-Ekanem, Director of Diversity/Civil Rights at 617-292-5751.
TTY# MassRelay Service 1-800-439-2370
MassDEP Website: www.mass.gov/dep

Printed on Recycled Paper

I. SPECIAL CONDITIONS

A. Effluent Limits

1) The permittee is authorized to discharge into the ground from the wastewater treatment facilities for which this permit is issued a treated effluent whose characteristics within one month of startup and continuing thereafter shall not exceed the following values:

Effluent Characteristics	Discharge Limitations
Flow	Phase 1: 228,900 gpd (annual average) 595,100 gpd (maximum day) Phase 2: 350,000 gpd (annual average) 883,800 gpd (maximum day)
Oil and grease	15 mg/l
Total Suspended Solids (TSS)	30 mg/l
Total Nitrogen ($NO_2 + NO_3 + TKN$)	10 mg/l
Nitrate-Nitrogen	10 mg/l
Biochemical Oxygen Demand, 5-day @20°C (BOD_5)	30 mg/l
Settleable Solids	0.1 ml/l
Fecal Coliform	200 colonies/100 ml
Total Residual Chlorine	4 mg/l

a) The pH of the effluent shall not be less than 6.5 nor greater than 8.5 at any time or not more than 0.2 standard units outside the range measured at the upgradient monitoring wells (LH-6 and MW-14).

b) Prior to discharging Phase 2 flow, the Permittee shall evaluate the operational experience with the wicks to determine if the wicks at 32 Lots Hollow Road are capable of accommodating the maximum day flow. Pending the results of that evaluation, the Department reserves the right to require development of additional wicks with plans to be submitted by the Permittee through a BRP WP 68 Treatment Works Plan Approval Without Permit Modification.

c) The compliance sampling point for Total Residual Chlorine shall be at the end of the force main prior to discharge into the wicks.

d) Redevelopment and cleaning of the wicks may periodically require dosages of chlorine in excess of the effluent limit. Redevelopment and cleaning procedures and protocols shall be included in the WWTF's Operation and Maintenance Manual (O&M) as approved by the Department. The permittee shall provide the Department with a 24 hour notification in advance of any redevelopment and cleaning activity, except in an instance of extreme emergency in which case notification shall be within 24 hours of emergency redevelopment and cleaning activity.

e) The discharge of the effluent shall not result in any demonstrable adverse effect on the groundwater or violate any water quality standards that have been promulgated.

f) The monthly average concentration of BOD and TSS in the discharge shall not exceed 15 percent of the monthly average concentrations of BOD and TSS in the influent into the permittee's wastewater treatment facility.

g) When the average annual flow exceeds 80 percent of the permitted flow limitations, the permittee shall submit a report to the Department describing what steps the permittee will take in order to remain in compliance with the permit limitations and conditions, inclusive of the flow limitations established in this permit.

B. Monitoring and Reporting

1) The permittee shall monitor and record the quality of the **influent** and the quality and quantity of the **effluent** prior to discharge to the leaching facilities according to the following schedule and other provisions:

INFLUENT:

Parameter	Minimum Frequency of Analysis	Sample Type
pH	Daily	Grab
Septage (quantity)	Daily	report
TSS	Weekly	24-hr Composite
BOD_5	Monthly	24-hr Composite
Oil & Grease	Monthly	Grab
Total Nitrogen ($NO_2 + NO_3 + TKN$)	Monthly	24-hr Composite
Sodium	Monthly	Grab
Chloride	Monthly	Grab
Volatile Organic Compounds	Quarterly	Grab

EFFLUENT:

Parameter	Minimum Frequency of Analysis	Sample Type
Flow	Daily	Continuous reading
pH	Daily	Grab
BOD_5	Monthly	24-hr Composite
Total Nitrogen (NO_2+NO_3+TKN)	Monthly	24-hr Composite
Nitrate Nitrogen	Monthly	24-hr Composite
Ammonia as Nitrogen	Monthly	24-hr Composite
Total Suspended Solids	Weekly	24-hr Composite
Settleable Solids	Weekly	Grab
Total Dissolved Solids	Weekly	Grab
Total Solids	Weekly	Grab
Oil & Grease	Monthly	Grab
Fecal Coliform	Monthly	Grab
Total Phosphorus	Quarterly	Grab
Orthophosphate	Quarterly	Grab
Total Residual Chlorine	If and When Applied	Grab
Volatile Organic Compounds	Annually	Grab

a) After one full year of monitoring the Total Phosphorus and Orthophosphate results, the Department may determine, upon the request of the permittee, that the frequency of monitoring may be reduced if, in the judgment of the Department, the results of the sampling indicate that existing phosphorus levels will not adversely impact downgradient receptors. If the Department reduces the frequency of monitoring for Total Phosphorus and Orthophosphate, the Department reserves the right to resume more frequent monitoring if the Department determines that phosphorus levels are impacting downgradient receptors.

b) Total Residual Chlorine shall only be reported if it is added to the treatment process as part of wick well maintenance. Use of chlorine shall be noted in the monthly discharge monitoring reports and effluent concentrations shall be noted at that time.

c) Testing for Total Suspended Solids (TSS), Total Dissolved Solids (TDS), and Total Solids (TS) is to monitor for solids discharging to the wicks.

2) The permittee shall install the approved monitoring wells at least 90 days prior to treatment facility start-up. The permittee shall install the upgradient monitoring wells, LH-6 and MW-14 and the downgradient monitoring wells LH-7, LH-8 and LH-9 as shown on the approved plan titled "Figure 11, Groundwater Monitoring Locations 32 and 43 Lots Hollow Road" as found in the " Project Summary of the Groundwater Discharge Permit (GWDP) Application 32 and 43 Lots Hollow Road, Town of Orleans, Massachusetts" prepared by AECOM Technical Services, Inc. and dated July 24, 2019. Labels identifying each monitoring well's identification in accordance with the above-referenced approved plan shall be affixed to the steel protective casing of each monitoring well.

The permittee shall monitor, record and report the quality of water in the approved monitoring wells according to the following schedule and other provisions:

Parameter	**Sample type**	**Sampling Frequency**
pH	Grab	Monthly
Static Water Level Elevation	Measurement	Monthly
Specific Conductance	Grab	Monthly
Total Nitrogen	Grab	Quarterly
Nitrate Nitrogen	Grab	Quarterly
Total Phosphorus	Grab	Quarterly
Orthophosphate	Grab	Quarterly
Volatile Organic Compounds	Grab	Annually

a) Static Water Level shall be expressed as an elevation and shall be referenced to the surveyed datum established for the site. It shall be calculated by subtracting the depth to the water table from the surveyed elevation of the top of the monitoring well's PVC well casing/riser.

b) After one full year of monitoring the Total Phosphorus and Orthophosphate results, the Department may determine, upon the request of the permittee, that the frequency of monitoring may be reduced if, in the judgment of the Department, the results of the sampling indicate that existing phosphorus levels will not adversely impact downgradient receptors. If the Department reduces the frequency of monitoring for Total Phosphorus and Orthophosphate, the Department reserves the right to resume more frequent monitoring if the Department determines that phosphorus levels are impacting downgradient receptors.

3) Any grab sample or composite sample required to be taken less frequently than daily shall be taken during the period of Monday through Friday inclusive. All composite samples shall be taken over a 24 hour period.

4) The permittee shall submit all monitoring reports within 30 days of the last day of the reporting month to MassDEP and to the Board of Health, 59 School Road, Orleans, Massachusetts 02653. All discharge monitoring reports submitted to MassDEP must be submitted through eDEP. To register for electronic submission go to: **http://www.mass.gov/eea/agencies/massdep/service/online/edep-online-filing.html**

C. Supplemental Conditions

1) The permittee shall notify the Department at least thirty (30) days in advance of the proposed transfer of ownership of the facility for which this permit is written. Said notification shall include a written agreement between the existing and new permittees containing a specific date for transfer of permit, responsibility, coverage and liability between them.

2) A staffing plan for the facility shall be submitted to the Department once every two years and whenever there are staffing changes. The staffing plan shall include the following components:

a) The operator(s)'s name(s), operator grade(s) and operator license number(s);
b) The number of operational days per week;
c) The number of operational shifts per week;
d) The number of shifts per day;
e) The required personnel per shift;
f) Saturday, Sunday and holiday staff coverage;
g) Emergency operating personnel

The initial staffing plan will be submitted to the Department prior to the wastewater treatment facility's clean water test.

3) The permittee is responsible for the operation and maintenance of all sewers, pump stations, and treatment units for the permitted facility, which shall be operated and maintained under the direction of a properly certified wastewater operator.

4) Operation and maintenance of the proposed facility must be in accordance with 314 CMR 12.00, "Operation and Maintenance and Pretreatment Standards for Wastewater Treatment Works and Indirect Discharges", and, 257 CMR 2.00, "Rules and Regulations for Certification of Operators of Wastewater Treatment Facilities".

a) The facility has been rated (in accordance with 257 CMR 2.00), to be a Grade 5 facility. Therefore, the permittee shall provide for oversight by a Massachusetts Certified Wastewater Treatment plant operator (Chief Operator) Grade 5 or higher. The permittee will also provide for a backup operator who shall possess at least a valid Grade 5 license.

b) The date and time of the operator's inspection along with the operator's name and certification shall be recorded in the log book on location at the treatment facility. All daily inspection logs consistent with the O&M Manual requirements shall be kept at the facility for a period of three (3) years.

c) Records of operation of wastewater treatment facilities or disposal systems required by the Department shall be submitted on forms supplied by the Department or on other forms approved by the Department for such use. Monthly reports shall be certified by the wastewater treatment plant operator in charge and shall be included in the discharge monitoring reports submitted each month.

5) If the operation and maintenance of the facility is to be contracted to a private concern, the permittee shall submit a copy of the contract, consistent with what is required by the approved Operation & Maintenance manual and signed only by the contractor, to the appropriate MassDEP Regional Office for review and approval ninety (90) days **prior** to the start up of the facility. Along with the contract, a detailed listing of all contract operation obligations of the proposed contractor at other facilities shall also be submitted. The permittee shall not begin operation of the treatment facility until the Department approves the contract.

6) All tests or analytical determinations to determine compliance with permit standards and requirements:

a) Effluent samples shall be collected, transported and stored in accordance with *Standard Methods for the Examination of Water and Wastewater;*

b) Monitoring must be conducted according to test procedures approved under 40 CFR Part 136 unless other methods are approved by the Department; and,

c) Samples shall be analyzed by a Massachusetts Certified laboratory unless otherwise approved by the Department.

7) The permittee shall notify the appropriate MassDEP Regional Office, in writing, within thirty (30) days of the following events:

a) The date of treatment plant start up.
b) Any interruption of the treatment system operation, other than routine maintenance.
c) Final shutdown of the treatment system.

8) The permittee shall contract to have any and all solids and sludges generated by the treatment system for which this permit is issued removed off site by a properly licensed waste hauler for disposal at an EPA/MassDEP approved facility. The name and license number of the hauler along with the quantity of wastes removed and the date(s) of removal shall be reported by the permittee in writing to the appropriate MassDEP Regional Office.

9) Simultaneously with the permit renewal application at year fifteen (2035) following the initiation of plant operations, the permittee shall submit two reports to the Department for its review and approval:

   a) An engineering report, prepared by a registered professional engineer, that outlines in sufficient detail what modifications (if any) to the facility or other changes are required to insure that the facility can remain in compliance with its GWDP and other applicable requirements through the next 5 year permit term (year 2040) and beyond; and

10) In the event that effluent limits are not met, or the discharge is determined to impair groundwater quality in accordance with 314 CMR 5.16(1), the permittee may be obligated to modify, supplement or replace the permitted treatment process so as to ensure that the discharge does not impair the ability of the groundwater to act as an actual or potential source of potable water.

11) Pursuant to M.G.L. Chapter 21A, section 18(a), and 310 CMR 4.03, holders of this Permit may be subject to annual compliance assurance fees as assessed each year on July 1st and invoiced by MassDEP. Failure of the Permit holder to pay applicable annual compliance assurance fees shall result in the automatic suspension of the permit by operation of law under the statute. If fee non-payment continues for sixty days or more, MassDEP has the statutory option of revoking the Permit, denying any other pending permit applications filed by the Permit holder or taking other enforcement action. Permit holders are required to notify MassDEP in writing if they wish to relinquish or transfer a permit. Failure to do so will result in the continued assessment of fees.

D. Appeal Rights

During the thirty (30) day period following issuance of this permit, a Notice of Claim for an Adjudicatory Appeal may be sent by any person aggrieved (the "Petitioner") by the issuance to:

Case Administrator
Office of Appeals and Dispute Resolution
Massachusetts Department of Environmental Protection
One Winter Street/2nd Floor
Boston, MA 02108

310 CMR 1.01(6)(b) requires the Notice of Claim to: include sufficient facts to demonstrate aggrieved person status; state the facts which are grounds for the appeal specifically, clearly and concisely; and, state relief sought. The permit shall become or remain effective at the end of the 30 day appeal period unless the person filing the Notice of Claim requests, and is granted, a stay of its terms and conditions. If a permit is modified under 314 CMR 2.10, only the modified terms and conditions may be subject to an Adjudicatory Appeal. All other aspects of the existing permit shall remain in effect during any such Adjudicatory Appeal.

Per 310 CMR 4.06, the hearing request to the Commonwealth will be dismissed if the filing fee is not paid. Unless the Petitioner is exempt or granted a waiver, a valid check payable to the Commonwealth to Massachusetts in the amount of $100.00 must be mailed to:

Commonwealth of Massachusetts
Department of Environmental Protection
P.O. Box 4062
Boston, MA 02211

The filing fee is not required if the Petitioner is a city, town, county, or district of the Commonwealth, federally recognized Indian tribe housing authority effective January 14, 1994, or any municipal housing authority; or, per MGL 161A s. 24, the Massachusetts Bay Transportation Authority. The Department may waive the adjudicatory hearing filing fee for a Petitioner who shows that paying the fee will create an undue financial hardship. A Petitioner seeking a waiver must file, along with the hearing request, an affidavit setting forth the facts believed to support the claim of undue financial hardship.

II. GENERAL PERMIT CONDITIONS

5.16: General Conditions

The following conditions apply to all individual and general permits:

(1) No discharge authorized in the permit shall cause or contribute to a violation of 314 CMR 4.00: *Massachusetts Surface Water Quality Standards*. Upon promulgation of any amended standard, the permit may be modified to comply with such standard in accordance with the procedures in 314 CMR 2.10: *Modification, Suspension, Revocation and Renewal of Permits and General Permit Coverage* and 314 CMR 5.12. Except as otherwise provided in 314 CMR 5.10(3)(c), 5.10(4)(a)2. and 5.10(9), no discharge authorized in the permit shall impair the ability of the ground water to serve as an actual or potential source of potable water. Evidence that a discharge impairs the ability of the ground water to serve as an actual or potential source of potable water includes, without limitation, analysis of samples taken in a downgradient well that demonstrates one or more exceedances of the applicable water quality based effluent limitations set forth in 314 CMR 5.10. In those cases where it is shown that a measured parameter exceeds the applicable water quality based effluent limitations set forth in 314 CMR 5.10 at the upgradient monitoring well, evidence that a discharge impairs the ability of the ground water to serve as an actual or potential source of potable water is deemed to exist if a measured parameter in any downgradient well exceeds the level of that same measured parameter in the upgradient well for the same sampling period. A statistical procedure approved by the Department shall be used to determine when a measured parameter exceeds the allowable level.

(2) Duty to Comply. The permittee shall comply at all times with the terms and conditions of the permit, 314 CMR 5.00, M.G.L. c. 21, §§ 26 through 53, and all applicable state and federal statutes and regulations.

(3) Standards and Prohibitions for Toxic Pollutants. The permittee shall comply with effluent standards or prohibitions established by § 307(a) of the Federal Act, 33 U.S.C. § 1317(a), for toxic pollutants within the time provided in the regulations that establish these standards or prohibitions, even if the permit has not yet been modified to incorporate the requirement.

(4) Proper Operation and Maintenance. The permittee shall at all times properly operate and maintain all facilities and equipment installed or used to achieve compliance with the terms and conditions of the permit, 314 CMR 12.00: *Operation and Maintenance and Pretreatment Standards for Wastewater Treatment Works and Indirect Discharges*, and 257 CMR 2.00: *Certification of Operators of Wastewater Treatment Facilities*. All equipment shall be maintained in an acceptable condition for its intended use.

(5) Duty to Halt or Reduce Activity. Upon reduction, loss, or failure of the treatment facility, the permittee shall, to the extent necessary to maintain compliance with its permit, control production, discharges, or both, until the facility is restored or an alternative method of treatment is provided. A permittee may not raise as a defense in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of the permit.

(6) Power Failure. In order to maintain compliance with the effluent limitations and prohibitions of the permit, the permittee shall either:

(a) provide an alternative power source sufficient to operate the wastewater control facilities; or

(b) halt, reduce or otherwise control production or all discharges upon the reduction, loss, or failure of the primary source of power to the wastewater control facilities.

(7) Duty to Mitigate. The permittee shall take all reasonable steps to minimize or prevent any adverse impact on human health or the environment resulting from non-compliance with the permit. Additionally, the permittee shall take all necessary steps to prevent an operational upset of the PWTF or POTW.

(8) Duty to Provide Information. The permittee and any operator of the permitted facility shall furnish to the Department within a reasonable time as specified by the Department any information which the Department may request to determine whether cause exists for modifying, suspending, revoking and reissuing, or terminating the permit, or to determine whether the permittee is complying with the terms and conditions of the permit.

(9) Inspection and Entry. The permittee shall allow the Department or its authorized representatives to:

(a) Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records required by the permit are kept;

(b) Have access to and copy, at reasonable times, any records that must be kept under the conditions of the permit;

(c) Inspect at reasonable times any facilities, equipment, practices, or operations regulated or required under the permit; and

(d) Sample or monitor at reasonable times for the purpose of determining compliance with the terms and conditions of the permit.

(9A) The permittee shall physically secure the treatment works and monitoring wells and limit access to the treatment works and monitoring wells only to those personnel required to operate, inspect and maintain the treatment works and to collect samples.

(9B) The permittee shall identify each monitoring well by permanently affixing to the steel protective casing of the well a tag with the identification number listed in the permit.

(10) Monitoring. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity. Monitoring must be conducted according to test procedures approved under 40 CFR Part 136 unless other test procedures are specified in the permit.

(11) Recordkeeping. The permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by the permit, and all records of all data used to complete the application for the permit, for a period of at least five years from the date of the sample, measurement, report or application. This period may be extended by request of the Department at any time. Records of monitoring information shall include without limitation:

(a) The date, exact place, and time of sampling or measurements;
(b) The individual(s) who performed the sampling or measurement;
(c) The date(s) analyses were performed;
(d) The individual(s) who performed the analyses;
(e) The analytical techniques or methods used; and
(f) The results of such analyses.

(12) Prohibition of Bypassing. Except as provided in 314 CMR 5.16(13), bypassing is prohibited and the Department may take enforcement action against a permittee for bypassing unless:

(a) The bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;
(b) There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if the permittee could have installed adequate backup equipment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance; and
(c) The permittee submitted notice of the bypass to the Department:
1. In the event of an anticipated bypass, at least ten days in advance, if possible; or
2. In the event of an unanticipated bypass, as soon as the permittee has knowledge of the bypass and no later than 24 hours after its first occurrence.

(13) Bypass not Exceeding Limitations. The permittee may allow a bypass to occur which does not cause effluent limitations to be exceeded, but only if necessary for the performance of essential maintenance or to assure efficient operation of treatment facilities.

(14) Permit Actions. The permit may be modified, suspended, or revoked for cause. The filing of a request by the permittee for a permit modification, reissuance, or termination, or a notification of planned changes or anticipated non-compliance does not stay any permit condition.

(15) Duty to Reapply. If the permittee wishes to continue an activity regulated by the permit after the expiration date of the permit, the permittee must apply for and obtain a new permit. The permittee shall submit a new application at least 180 days before the expiration date of the existing permit, unless permission for a later date has been granted by the Department in writing.

(16) Property Rights. The permit does not convey any property rights of any sort or any exclusive privilege.

(17) Other Laws. The issuance of a permit does not authorize any injury to persons or property or invasion of other private rights, nor does it relieve the permittee of its obligation to comply with any other applicable Federal, State, or local law, or regulation.

(18) Oil and Hazardous Substance Liability. Nothing in the permit shall be construed to preclude the institution of any legal action or relieve the permittee of any responsibilities, liabilities, or penalties to which the permittee is or may be subject under § 311 of the Federal

Act, 33 U.S.C. § 1321, and M.G.L. c. 21E.

(19) Removed Substances. Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed in a manner consistent with applicable Federal and State laws and regulations including, but not limited to, the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26 through 53, and the Federal Act, 33 U.S.C. § 1251 *et seq.*, the Massachusetts Hazardous Waste Management Act, M.G.L. c. 21C, and the Federal Resource Conservation and Recovery Act, 42 U.S.C. § 6901, *et seq.*, 310 CMR 19.000: *Solid Waste Management* and 310 CMR 30.000: *Hazardous Waste*.

(20) Reporting Requirements.

(a) Monitoring Reports. Monitoring results shall be reported on a Discharge Monitoring Report (DMR) at the intervals specified in the permit. If a permittee monitors any pollutant more frequently than required by the permit, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the DMR. Beginning on December 2, 2017, a permittee shall submit all DMRs electronically, using the electronic reporting system designated by the Department. A permittee may seek a waiver of this requirement by submitting a written request for the Department's approval.

(b) Compliance Schedules. Reports of compliance or non-compliance with, or any progress reports on interim and final requirements contained in any compliance schedule in the permit shall be submitted no later than 14 days following each schedule date.

(c) Planned Changes. The permittee shall give notice to the Department as soon as possible of any planned physical alterations or additions to the permitted facility or activity which could significantly change the nature or increase the quantity of pollutants discharged. Unless and until the permit is modified, any new or increased discharge in excess of permit limits or not specifically authorized by the permit constitutes a violation.

(d) Anticipated Non-compliance. The permittee shall give advance notice to the Department of any planned changes in the permitted facility or activity which may result in non-compliance with permit requirements.

(e) 24 Hour Reporting. The permittee shall report any non-compliance which may endanger health or the environment. Any information shall be communicated orally within 24 hours of the time the permittee becomes aware of the circumstances. A written submission shall also be provided within five days of the time the permittee becomes aware of the circumstances. The written submission shall contain: a description of the non-compliance, including exact dates and times, and if the non-compliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent reoccurrence of the non-compliance. The following shall be included as information which must be reported within 24 hours:

1. Any unanticipated bypass which exceeds any effluent limitation in the permit; and
2. Any violation of a maximum daily discharge limitation for any of the pollutants required by the permit to be reported within 24 hours.

(f) Other Non-compliance. The permittee shall report all instances of non-compliance not reported under 314 CMR 5.16(20)(a), (b), or (e) at the time monitoring reports are submitted. The reports shall contain the information listed in 314 CMR 5.16(20)(e).

(g) Toxics. All manufacturing, commercial, mining, or silvicultural dischargers must notify

the Department as soon as they know or have reason to believe:

1. That any activity has occurred, or will occur, that would result in the discharge of any toxic pollutant listed in 314 CMR 3.17: *Appendix B - Toxic Pollutants* not limited by the permit, if that discharge will exceed the highest of the following notification levels:

a. 100 micrograms per liter (100 ug/l);

b. 200 micrograms per liter (200 ug/l) for acrolein and acrylonitrile, 500 micrograms per liter (500 ug/l) for 2,4-dinitrophenol, and for 2-methyl-4,6-dinitrophenol, and one milligram per liter (1 mg/l) for antimony;

c. Five times the maximum concentration value reported for that pollutant in the permit application; or

2. That they have begun or expect to begin to use or manufacture as an intermediate or final product or byproduct any toxic pollutant which was not reported in the permit application.

(h) Indirect Dischargers. All Publicly Owned Treatment Works shall provide adequate notice to the Department of the following:

1. Any new introduction of pollutants into the POTW from an indirect discharger which would be subject to § 301 or § 306 of the Federal Act, 33 U.S.C. § 1311 or 1316, if it were directly discharging those pollutants; and

2. Any substantial change in the volume or character of pollutants being introduced into the POTW by a source introducing pollutants into the POTW at the time of issuance of the permit.

(i) Information. Where a permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the Department, it shall promptly submit the relevant facts or correct information.

(j) The permittee shall notify the Department in writing within seven days of any change in contract operators.

(21) Signatory Requirement. All applications, reports, or information submitted to the Department shall be signed and certified in accordance with 314 CMR 5.14 and 5.15.

(22) Severability. The provisions of the permit are severable. If any provision of the permit, or the application of any provision of the permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of the permit, shall not be affected thereby.

(23) Reopener Clause. The Department reserves the right to make appropriate revisions to the permit to establish any appropriate effluent limitations, schedules of compliance, or other provisions, as authorized by the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26 through 53, or the Federal Act, 33 U.S.C. § 1251 *et seq.*, to bring all discharges into compliance with these statutes.

(24) Approval of Treatment Works. All discharges and associated treatment works authorized in 314 CMR 5.00 shall remain in compliance with the terms and conditions of the permit. Any modification of the approved treatment works shall require written approval of the Department prior to the construction of the modification.

(25) Transfer of Permits.

(a) RCRA Facilities. Any permit which authorizes the operation of a RCRA facility subject to the requirements of 314 CMR 8.07: *Standards for all other RCRA Facilities* shall be valid only for the person to whom it is issued and may not be transferred.

(b) Transfers by Modification. Except as provided in 314 CMR 5.16(25)(a) and (c), a permit may be transferred by the permittee to a new permittee if the permit has been modified or revoked and reissued in accordance with 314 CMR 5.12(2), or a minor modification is made to identify the new permittee in accordance with 314 CMR 5.12(3) and (4).

(c) Automatic Transfers. For facilities other than Privately Owned Wastewater Treatment Facilities (PWTFs) that treat at least some sewage from residential uses, hospitals, nursing or personal care facilities, residential care facilities, or assisted living facilities, PWTFs that have been required to establish, fund and maintain financial assurance mechanism(s) pursuant to 314 CMR 5.15(6), and RCRA facilities subject to the requirements of 314 CMR 8.07: *Standards for all other RCRA Facilities*, a permit may be automatically transferred in accordance with 314 CMR 5.12(5).

(26) Permit Compliance Fees and Inspection Information. Except as otherwise provided, any permittee required to obtain a ground water discharge permit pursuant to M.G.L. c. 21, § 43, and 314 CMR 5.00 shall submit the annual compliance assurance fee established in accordance with M.G.L. c. 21A, § 18 and 310 CMR 4.00: *Timely Action Schedule and Fee Provisions*, as provided in 314 CMR 2.12: *Applications, Fees and Inspection Information.* The requirement to submit the annual compliance fee does not apply to any local government unit other than an authority. Any permittee required to obtain a ground water discharge permit pursuant to M.G.L. c. 21, § 43 and 314 CMR 5.00, may be required to submit inspection information annually, as provided in 314 CMR 2.12.

Massachusetts Department of Environmental Protection
One Winter Street, Boston MA 02108 • Phone: 617-292-5751
Communication For Non-English Speaking Parties - 310 CMR 1.03(5)(a)



1 English:

This document is important and should be translated immediately. If you need this document translated, please contact MassDEP's Diversity Director at the telephone numbers listed below.



2 Español (Spanish):

Este documento es importante y debe ser traducido inmediatamente. Si necesita este documento traducido, por favor póngase en contacto con el Director de Diversidad MassDEP a los números de teléfono que aparecen más abajo.



3 Português (Portuguese):

Este documento é importante e deve ser traduzida imediatamente. Se você precisa deste documento traduzido, por favor, entre em contato com Diretor de Diversidade da MassDEP para os números de telefone listados abaixo.



4(a) 中國（傳統）(Chinese (Traditional):

本文件非常重要，應立即翻譯。如果您需要翻譯這份文件，請用下面列出的電話號碼與Mass DEP的多樣性總監聯繫。



4(b) 中国（简体中文）(Chinese (Simplified):

本文件非常重要，应立即翻译。如果您需要翻译这份文件，请用下面列出的电话号码与Mass DEP的多样性总监联系。



5 Ayisyen (franse kreyòl) (Haitian) (French Creole):

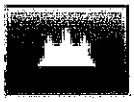
Dokiman sa-a se yon bagay enpòtan epi yo ta dwe tradui imedyatman. Si ou bezwen dokiman sa a tradui, tanpri kontakte Divèsite Direktè MassDEP a nan nimewo telefòn ki nan lis pi ba a.



6 Việt (Vietnamese):

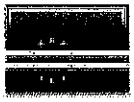
Tài liệu này là rất quan trọng và cần được dịch ngay lập tức. Nếu bạn cần dịch tài liệu này, xin vui

lòng liên hệ với Giám đốc MassDEP đa dạng tại các số điện thoại được liệt kê dưới đây.



7 ប្រទេសកម្ពុជា (Kmer (Cambodian):

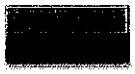
ឯកសារនេះគឺមានសារៈសំខាន់និងគួរត្រូវបានបកប្រែភ្លាម។ ប្រសិនបើអ្នកត្រូវបានបកប្រែ ឯកសារនេះសូមទំនាក់ទំនងឆ្មោតជានាយក MassDEP នៅលេខទូរស័ព្ទដែលបានរាយខាងក្រោម។



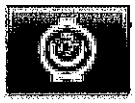
8 Kriolu Kabuverdianu (Cape Verdean):

Es documento é importante e deve ser traduzido imidiatamente. Se bo precisa des documento traduzido, por favor contacta Director de Diversidade na MassDEP's pa es numero indicode li d'boche.

9 Русский язык (Russian):

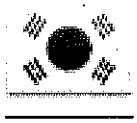


Этот документ является важным и должно быть переведено сразу. Если вам нужен этот документ переведенный, пожалуйста, свяжитесь с директором разнообразия MassDEP по адресу телефонных номеров, указанных ниже.



10 العربية (Arabic):

هذه الوثيقة الهامة وينبغي أن تترجم على الفور. اذا كنت بحاجة الى هذه الوثيقة المترجمة، يرجى الاتصال مدير التنوع في MassDEPعلى أرقام الهواتف المدرجة أدناه.



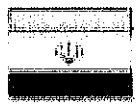
11 한국어 (Korean):

이 문서는 중요하고 즉시 번역해야합니다. 당신이 번역이 문서가 필요하면 아래의 전화 번호로 MassDEP의 다양성 감독에 문의하시기 바랍니다.



12 հայերեն (Armenian):

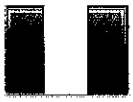
Այս փաստաթուղթը շատ կարեւոր է եւ պետք է թարգմանել անմիջապես. Եթե Ձեզ անհրաժեշտ է այս փաստաթուղթը թարգմանվել դիմել MassDEP բազմազանությունը տնօրեն է հետախոսահամարների թվարկված են ստորեւ.



13 فارسی (Farsi (Persian):

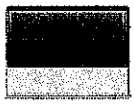
این سند مهم است و باید فورا ترجمه شده است.

اگر شما نیاز به این سند ترجمه شده، لطفا با ما تماس تنوع مدیر MassDEP در شماره تلفن های ذکر شده در زیر.



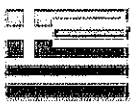
14 Français (French):

Ce document est important et devrait être traduit immédiatement. Si vous avez besoin de ce document traduit, s'il vous plaît communiquer avec le directeur de la diversité MassDEP aux numéros de téléphone indiqués ci-dessous.



15 Deutsch (German):

Dieses Dokument ist wichtig und sollte sofort übersetzt werden. Wenn Sie dieses Dokument übersetzt benötigen, wenden Sie sich bitte Diversity Director MassDEP die in den unten aufgeführten Telefonnummern.



16 Ελληνική (Greek):

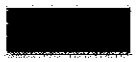
Το έγγραφο αυτό είναι σημαντικό και θα πρέπει να μεταφραστούν αμέσως. Αν χρειάζεστε αυτό το έγγραφο μεταφράζεται, παρακαλούμε επικοινωνήστε Diversity Director MassDEP κατά τους αριθμούς τηλεφώνου που αναγράφεται πιο κάτω.



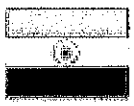
17 Italiano (Italian):

Questo documento è importante e dovrebbe essere tradotto immediatamente. Se avete bisogno di questo documento tradotto, si prega di contattare la diversità Direttore di MassDEP ai numeri di telefono elencati di seguito.

18 Język Polski (Polish):



Dokument ten jest ważny i powinien być natychmiast przetłumaczone. Jeśli potrzebujesz tego dokumentu tłumaczone, prosimy o kontakt z Dyrektorem MassDEP w różnorodności na numery telefonów wymienionych poniżej.



19 हिन्दी (Hindi):

यह दस्तावेज महत्वपूर्ण है और तुरंत अनुवाद किया जाना चाहिए. आप अनुवाद इस दस्तावेज़ की जरूरत है, नीचे सूचीबद्ध फोन नंबरों पर MassDEP की विविधता निदेशक से संपर्क करें.

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection
Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Kathleen A. Theoharides
Secretary

Martin Suuberg
Commissioner

September 27, 2021

Mr. Thomas E. Parece, P.E.
AECOM Technical Services, Inc.
250 Apollo Drive
Chelmsford, Massachusetts 01824

City/Town: Orleans
RE: Hydrogeologic Disposal Modification
Facility Name: GW#933-0 Orleans WWTF
Authorization Type: Approval

Dear Mr. Parece:

The Massachusetts Department of Environmental Protection (MassDEP) has completed its review of the application for modification of the design of the Wick Discharge for the Orleans Wastewater Treatment facility.

As part of the application submitted by AECOM on June 14, 2021, MassDEP received the following:

1. One (1) Typical Wick Design Plan Sheet with the following Title:

DOWNTOWN AREA WWTF
AND
EFFLUENT DISPOSAL
CONTRACT NO. 2019-1 SRF NO. 4486
SHEET NUMBER 99 C-505

2. A summary of wick volume and surface area calculation sheet

3. The MassDEP approved Lots Hollow Hydrogeological report

Pursuant to 314 CMR 5.09 (1) (f), MassDEP hereby **approves** the modification to the Wicks Design by AECOM subject to the following conditions:

1. The design flow of the proposed groundwater discharge shall not exceed 500,000 gallons per day at either 32 or 43 Lots Hollow Road.

2. The proposed wicks shall be constructed within the footprints indicated on Figures 4 and 5, found in the MassDEP approved Hydrogeologic Report.

3. There are private wells which might be affected by the discharge at the site and will need to connect to the Town of Orleans public water supply or be monitored on an annual basis for adverse impacts.

4. There is possible impact of mounding on the marshes; therefore, monitoring of the species present is recommended prior to discharge to document any potential changes during discharge commencement.

5. An Initial Groundwater Monitoring Well and Groundwater Quality Report must be submitted to this office prior to any discharge of wastewater. This report must include:

    a. a final surveyed site plan with location of the wick wells, all monitoring wells and all appropriate elevation data,

    b. boring logs and well construction details for all monitoring wells, and

    c. the analytical results of the groundwater samples collected from the final groundwater monitoring wells. These results will establish the baseline groundwater quality for the site.

If you have questions regarding the comments and conditions of this approval, please contact Steve Hallem at (617) 292-5681 or Stephen.hallem@state.ma.us .

Sincerely,

Gerard M.R. Martin for:
Brian Dudley, Section Chief
Wastewater Management – Cape and Islands

ecc: Mr. John Kelly
19 School Road
Orleans, MA 02653
jkelly@town.orleans.ma.us

Mr. Ian Catlow
Tighe and Bond, Inc.
446 Main Street
Worcester, MA
ibcatlow@tighebond.com

Mr. Mark Owen
AECOM
9 Jonathon Bourne Drive
Pocasset, MA 02559
mark.owen@aecom.com

DEP/Boston
Attn: Stephen Hallem

ATTACHMENT G

TECHNICAL MEMORANDUM – SITE CHARACTERIZATION AND EVALUATION FOR FLOATING CONSTRUCTED WETLANDS

AECOM
9 Jonathan Bourne Drive
Pocasset, MA 02559
www.aecom.com

508.833.6950 tel
508.833.6951 fax

Memorandum

To	George Meservey, Director of Planning & Community Development Michael Domenica, PE, Program Manager
CC	Betsy Shreve, AICP, AECOM Project Director Terry Doss, Biohabitats Inc. Pete Munoz, Biohabitats Inc. Jennifer Doyle-Breen, AECOM Paula Winchell, AECOM
Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 3 – Non Traditional Demonstration Projects** **Deliverable 3.a.1 - Final Technical Memorandum for Site Characterization and Evaluation for Floating Constructed Wetlands**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	May 25, 2016

1. Background

a. Purpose

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. Orleans' water resources have been degraded due to nutrient enrichment, primarily from the disposal of wastewater. 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 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. This Memorandum includes the following:

- Description of the initial process employed to develop the Orleans Consensus Plan and associated potential demonstration sites;
- Next steps taken in the process of evaluating demonstration sites;
- Review of available data to understand current site conditions and evaluate potential demonstration sites;

- Evaluation, rating and ranking of sites based on the site selection matrix and criteria; and
- The recommended demonstration site and the rationale for its selection.

In addition, key terms are defined including the categories of data that were evaluated. The site selection criteria and rating system used to assess potential demonstration sites are also explained.

The purpose of this documentation is to provide a transparent and objective assessment of possible locations in Orleans to site FCW Non-Traditional technology demonstration projects. The assessment will be used to select the best possible site for preliminary engineering, which will include drawings, preliminary specifications, cost estimates, funding sources and monitoring plans.

b. Glossary of Floating Constructed Wetlands Terms and Key Design Features

To establish a consistent meaning of FCW in the context of this Technical Memorandum, this term is defined as follows:

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 following core design principals that will be followed in the design of the FCWs are to:

- Utilize natural, low-tech treatment technologies where possible;
- Minimize energy use and mechanical system complexity;
- Incorporate educational and interpretive value into the system; and
- Develop systems that are easy to maintain and operate to enhance long-term viability.

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 the 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.

To provide an understanding of FCW, a few photos and diagrams of the systems are provided below.



Jamaica Bay Floating Wetland Wave Attenuator



Baltimore Harbor Floating Constructed Wetland

Below, a diagram from a floating wetland system currently being studied in Baltimore Harbor is provided which illustrates some of the functions provided by an FCW system.

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).

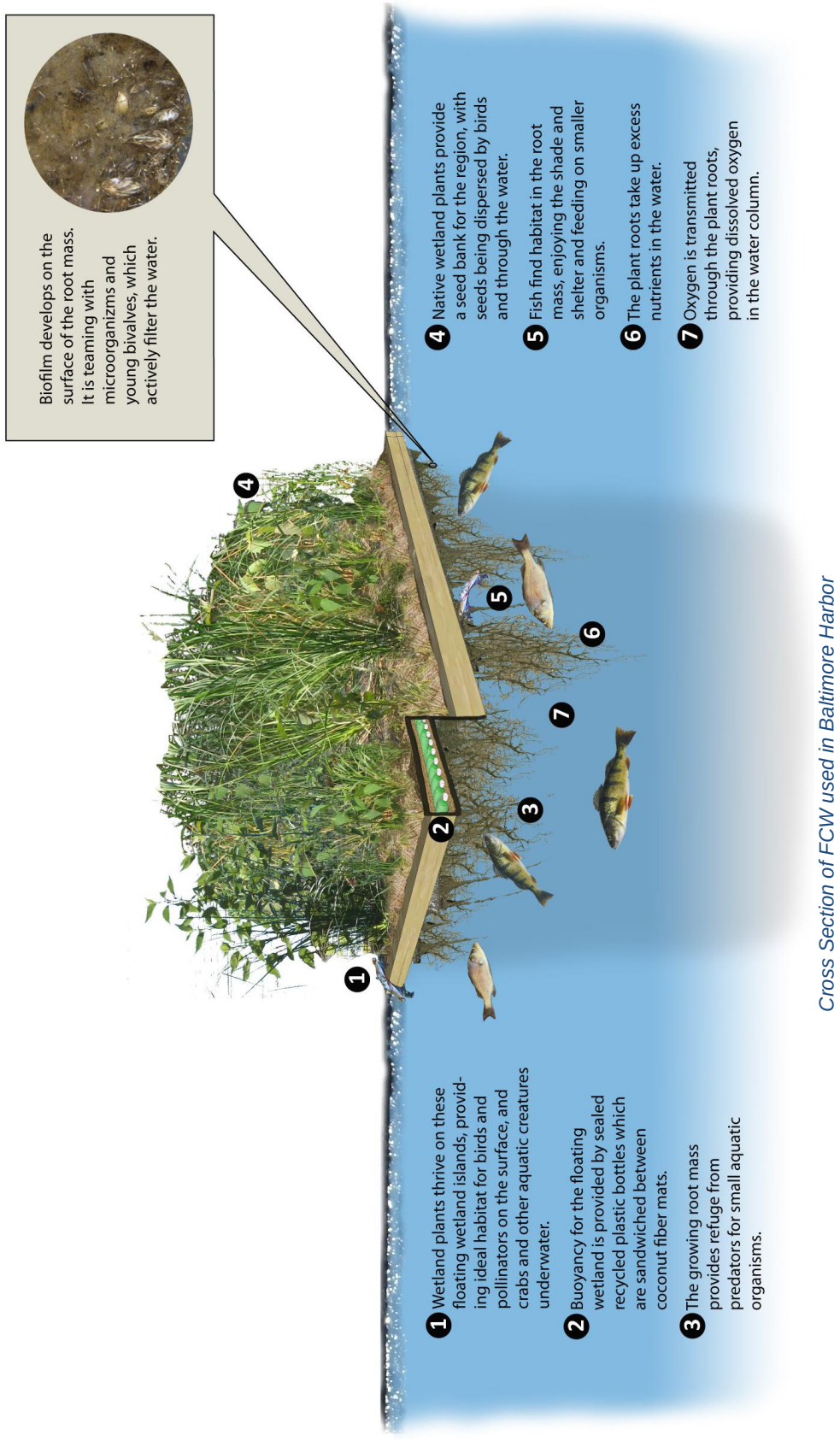
The FCW can be designed into any shape or size, but a typical section is rectangular. Any number of sections can be connected together by cables to create a unit.

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.

c. Goals and Objectives

The goal of this demonstration project is to evaluate the potential to use FCWs to:

- Reduce nutrients;
- Realize associated ecological and socioeconomic benefits;
- Evaluate uncertainties associated with the local climate and environmental conditions;



Cross Section of FCW used in Baltimore Harbor

- Assess local water quality and ecological benefits; and,
- Provide a case study to guide siting, design and monitoring of future projects.

The pilot project will be built as a temporary structure and will be monitored throughout the life of the project. If necessary, the structure can be removed at any time during the project or after the monitoring period is complete.

The immediate objectives of the proposed FCW demonstration project are to:

- Install temporary floating wetlands;
- Monitor the performance of the floating wetlands to reduce nitrogen in the surface water of the study area; and
- Infer quantitative decisions about the value of FCWs at meeting the long term goals of the Town of Orleans in reducing nitrogen in its water resources.

2. Introduction

a. Consensus Plan Overview

The Orleans Water Quality Advisory Panel, or OWQAP, was convened to achieve consensus and build widespread community support for a customized, affordable water quality management plan for the Town of Orleans. The panel consisted 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 starting in July 2014, 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. As discussed in further detail below in Section 2c, a Hybrid Plan was developed through an iterative process and included specific sites for the use of NT nitrogen removal technologies, including FCW, permeable reactive barriers, aquaculture and coastal habitat restoration. Once the feasibility of using FCW and other NT technologies as part of the Town's nutrient management strategy was established, the OWQAP decided that the final Consensus Plan would not specify exact site locations but instead focus on overall quantities of FCW and other NT technologies needed to remove the appropriate mass of nitrogen at the watershed level.

The resulting map (Figure 1), entitled Conceptual Approach to Meet Orleans Water Quality Goals (March 2015) shows the agreed upon water quality management plan and includes 1.5 acres of FCW in the Nauset Harbor watershed, 3 acres of FCW in the Pleasant Bay watershed, and 0.5 acre of FCW in the Rock Harbor Watershed. This map also specifies acreages for shellfish habitat and linear feet of PRBs.

Stantec

CONCEPTUAL APPROACH TO MEET ORLEANS WATER QUALITY GOALS

MARCH, 2015

TOWN OF ORLEANS
MASSACHUSETTS

N

0 600 1,200 2,400 3,600 4,800
Feet

Rock Harbor Watershed:

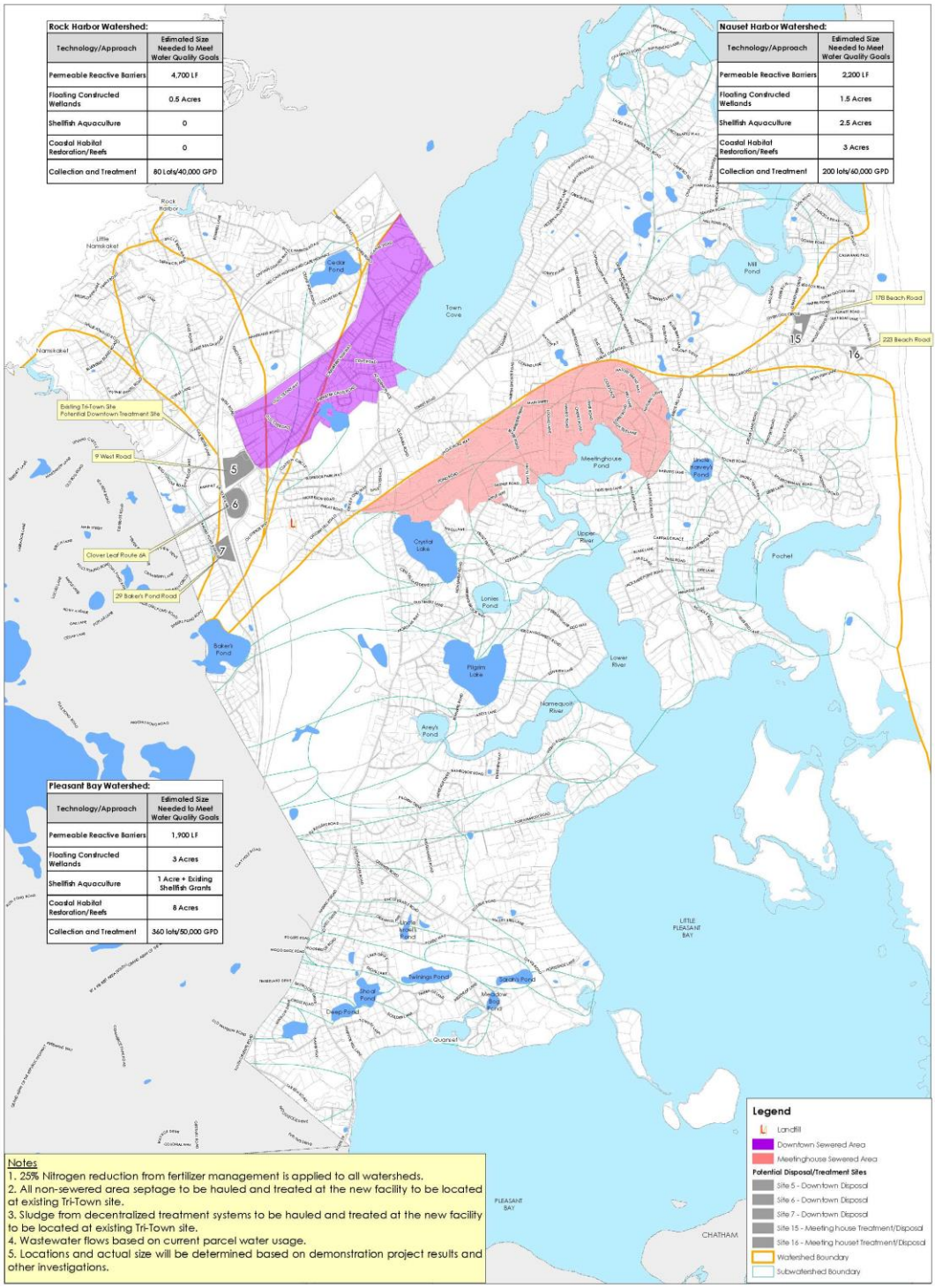
Technology/Approach	Estimated Size Needed to Meet Water Quality Goals
Permeable Reactive Barriers	4,700 LF
Floating Constructed Wetlands	0.5 Acres
Shellfish Aquaculture	0
Coastal Habitat Restoration/Reefs	0
Collection and Treatment	80 Lots/40,000 GPD

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



Notes
1. 25% Nitrogen reduction from fertilizer management is applied to all watersheds.
2. All non-sewered area septage to be hauled and treated at the new facility to be located at existing Tri-Town site.
3. Sludge from decentralized treatment systems to be hauled and treated at the new facility to be located at existing Tri-Town site.
4. Wastewater flows based on current parcel water usage.
5. Locations and actual size will be determined based on demonstration project results and other investigations.

b. Initial Process of Site Identification

As part of updating the 208 Plan, The Cape Cod Commission (CCC) created traditional and NT scenarios that would meet the regulatory requirements for nitrogen formalized as Total Maximum Daily Loads (TMDLs) for Orleans' impaired waterbodies. The traditional scenario for Orleans used centralized sewers exclusively. The NT scenario met nitrogen-removal goals through a subset of the many alternatives that are described in the 208 Plan's Technology Matrix. The subset of NT technologies in the Commission's NT Scenario included FCWs, permeable reactive barriers, coastal habitat restoration, shellfish aquaculture, fertigation, composting and urine-diverting toilets and innovative/alternative septic systems. In order to provide consistency with this established regulatory framework, the NT scenario developed by the Commission became the starting point for customizing a NT bookend for the OWQAP and consensus-building process.

This planning and design process for tailoring a NT bookend for Orleans included studying the information prepared by the CCC, and collecting and analyzing a significant amount of additional local data that were not reviewed as part of the regional planning process undertaken by the Commission. Local data from satellite images, GIS maps, groundwater maps, and coastal pond bathymetry data was reviewed, and then site visits both by land and by water were conducted to validate potential locations.

This local data collection and evaluation allowed the NT Bookend for Orleans to be based on key validated site parameters, to confirm that the NT technologies were feasible in their planned locations. In addition, a Technical Memorandum on NT Technologies (Appendix A) was prepared and submitted to the OWQAP. This Technical Memorandum detailed initial performance expectations, as well as key site and permitting considerations that should be used to verify the usefulness of these technologies for specific subwatersheds in Orleans.

The results of this detailed analysis and resulting initial locations for NT technologies were presented and discussed at the October 8, 2014 OWQAP Stakeholder meeting. Based on this technical review, as well as direction from the OWQAP, specific NT technologies were then selected to be used to create the "Hybrid Plan", which is further discussed below.

c. Hybrid Plan Site Identification Criteria used during OWQAP Process

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 would 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, a Technology Evaluation Decision Support Tool was developed to evaluate risks and benefits of each technology by subwatershed. Preliminary comparative costs were also presented on a relative dollars/kilogram of nitrogen removed basis. Spreadsheets with ratings and rankings for each subwatershed are included in Appendix B.

Ranked categories include:

- Nutrient removal certainty – Nitrogen (Saltwater) and Phosphorus (Freshwater);
- Implementation certainty;
- Other benefits including ecological, economic and social;
- Adaptability to uncertainty in nutrient-reduction goals and build-out;
- Contaminants of emerging concern removal; and
- Overall cost.

The list of potential water bodies identified during this process where FCW could be tested as a demonstration project included the following sites:

- Boland Pond;
- Crystal Lake;
- Lonnie's Pond;
- Mill Pond;
- Namequoit River;
- Paw Wah Pond;
- Pilgrim Lake;
- Pleasant Bay;
- Pochet Neck;
- Rock Harbor;
- Quanset Pond;
- Town Cove; and
- Upper River.

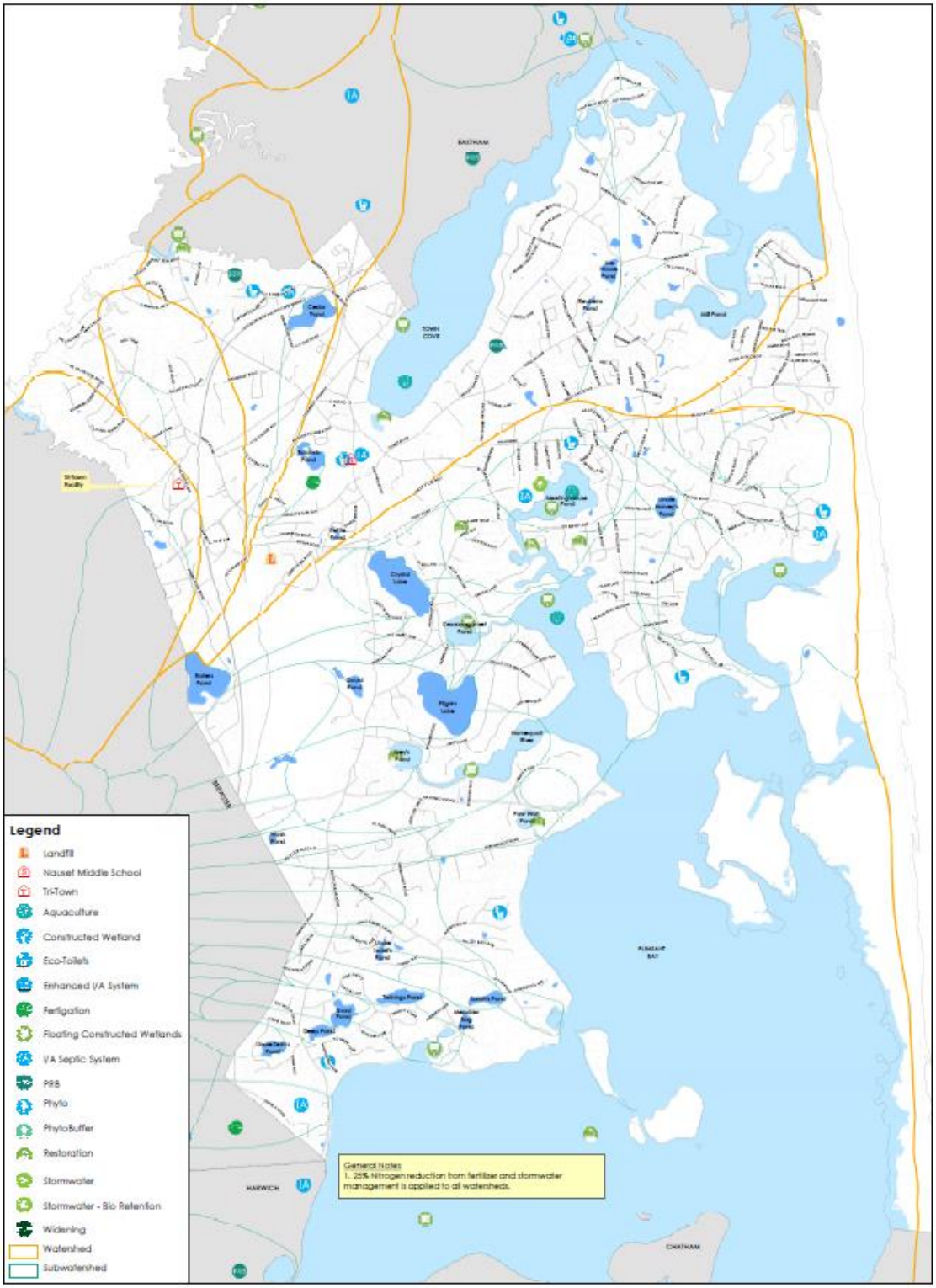
d. 2015 Site Reconnaissance

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 fall 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 the 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 narrow 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, as shown on Figure 2 – Preliminary Non-Traditional Scenario Map (September 2014), were:

- Lonnie's Pond;
- Mill Pond;
- Namequoit River;
- Paw Wah Pond;
- Pleasant Bay;
- Pochet Neck;
- Quanset Pond;
- Town Cove; and
- Upper River.


Legend
Landfill
Nauset Middle School
Tri-Town
Aquaculture
Constructed Wetland
Eco-Toilets
Enhanced I/A System
Fertigation
Floating Constructed Wetlands
I/A Septic System
PRB
Phyto
PhytoBuffer
Restoration
Stormwater
Stormwater - Bio Retention
Widening
Watershed
Subwatershed
General Notes
1. 25% Nitrogen reduction from fertilizer and stormwater management is applied to all watersheds.
Stantec
CCC 208 PRELIMINARY
NON-TRADITIONAL SCENARIO MAP
TOWN OF ORLEANS
MASSACHUSETTS
SEPTEMBER, 2014
N

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.

e. Sites Reviewed in Detail as Part of This Next Phase of Work

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 3 – Potential Floating Constructed Wetland Sites:

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

3. Description of Five Potential Sites

All sites selected as potential sites for the FCW demonstration project are small tributary sub-embayments of the Pleasant Bay Estuary, which is the largest embayment on Cape Cod. The tributary sub-embayments receive freshwater discharge, primarily in the form of groundwater discharge or groundwater fed surface water flow. Freshwater flows mix with incoming saltwater flows from twice daily tidal inundation. The sites then discharge to the Pleasant Bay Estuary during the twice daily outgoing tides. Due to these general characteristics, all sites have a number of general similar characteristics. Specific site conditions which were investigated are described below.

a. Common Parameters

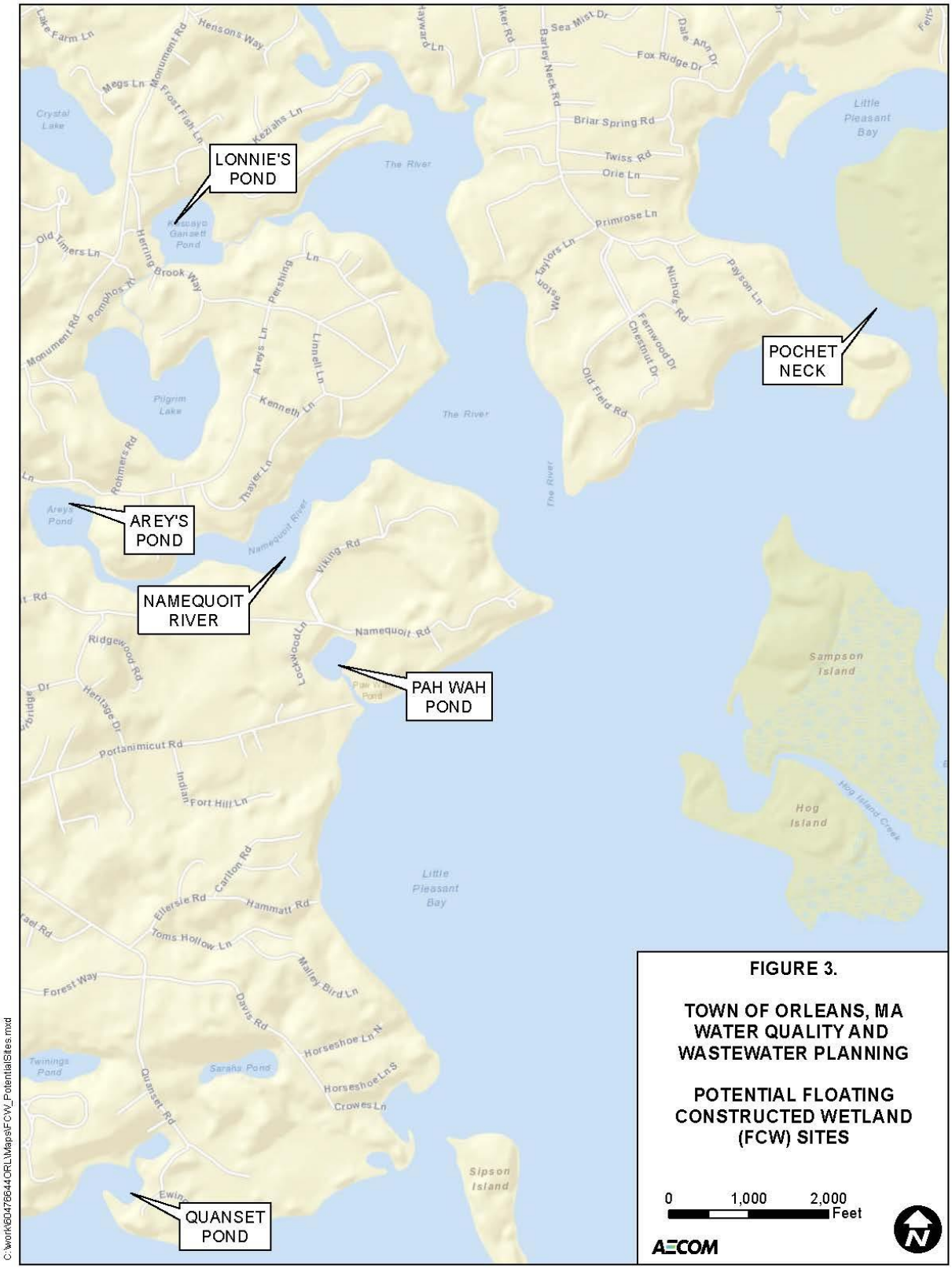
All sites are located within the Pleasant Bay Estuary Area of Critical Environmental Concern, as designated in 1987 because of the area's extraordinary natural resources.

All sites have general tide levels which range from about five to six feet. Bathymetry data from the National Oceanic and Atmospheric Administration (NOAA 2015) indicates that the depth of the Bay and its sub-embayments at mean low tide is approximately two to three feet in most areas.

Surface water conditions for the sites do not vary from sub-embayment to sub-embayment; for example, salinity in the sub-embayments is generally within the range of 29 – 31 ppt and surface water temperatures, which are regulated by environmental conditions rather than site conditions, generally range from 21 – 24 degrees F (Alliance 2009, Cadmus Group 2015).

These sites are generally characterized as small enclosed basins (except for the Namequoit River which is ultimately hydrologically linked with Arey's Pond, a small enclosed basin), and as such are at risk of eutrophication from high nitrogen loads entering via direct groundwater seepage in addition to surface water inflows from adjacent sub-watersheds.

Potential impairments to the water quality of these water bodies includes excess nutrients, low dissolved oxygen levels, high chlorophyll, excess macroalgae, and resultant degraded health of benthic fauna.


LONNIE'S POND
POCHET NECK
AREY'S POND
NAMEQUOIT RIVER
PAH WAH POND
QUANSET POND
The River
Little Pleasant Bay
Sampson Island
Hog Island
Sipson Island
Pilgrim Lake
Crystal Lake
Sarahs Pond
Twinings Pond
Namequoit Rd
Portanimicut Rd
Briar Spring Rd
Primrose Ln
Monument Rd
Herring Brook Way
Old Timers Ln
Pomphos Rd
Pershing Ln
Areys Ln
Linnell Ln
Kenneth Ln
Thayer Ln
Rohmers Rd
Viking Rd
Lockwood Ln
Ridgewood Rd
Heritage Dr
Indian Fort Hill Ln
Carlton Rd
Ellersie Rd
Hammatt Rd
Toms Hollow Ln
Forest Way
Davis Rd
Horseshoe Ln N
Horseshoe Ln S
Crowes Ln
Quanset Rd
Malley Bird Ln
Barley Neck Rd
Fox Ridge Dr
Sea Mist Dr
Dale Ann Dr
Twiss Rd
Orie Ln
Taylors Ln
Nichols Rd
Payson Ln
Fernwood Dr
Chestnut Dr
Old Field Rd
Megs Ln
Frost Fish Ln
Kezjahs Ln
Henson's Way
Lake Farm Ln
FIGURE 3.
TOWN OF ORLEANS, MA
WATER QUALITY AND
WASTEWATER PLANNING
POTENTIAL FLOATING
CONSTRUCTED WETLAND
(FCW) SITES
0
1,000
2,000
Feet
AECOM
C:\work\60476644\GRL\Maps\FCW_PotentialSites.mxd

Because of the similarities in the six 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. These site parameters are identified below.

Water flow: Determination of how water circulates through the water body to determine inputs and outputs to the system.

Bathymetry: Depth of the water body.

Other water uses: Type and location of activities that occur in the water and on land near the site, that limit, or enhance, the ability to install the demonstration project.

Abutter interests/potential conflicts: Any known issues which might be raised within the community or by neighboring land use owners due to the presence of a demonstration project.

Available acreage: The amount of square footage available to a site for purposes of the demonstration project, given boating activity and other water uses in the area.

Access points/easement requirements: Whether or not a convenient, public location is available and could be used to access the site for installation, operations and maintenance of the demonstration project.

Land ownership: Whether or not the site has parcels that are privately owned that would limit or preclude use of the site for demonstration purposes.

b. Synopsis of Existing Conditions for Each of the Five Sites

Each of the five sites selected for further review as potential demonstration sites for the FCW are described below using the site parameters listed in the previous section.

(1) **Lonnie's Pond** is an intertidal salt water pond located off of the upper section of The River, located in the upper reaches of Pleasant Bay. The only channel access to The River and the Bay is narrow. The 2006 MEP report estimates that existing nitrogen loads are 4.3 kg/day.

Water flow - In addition to the twice daily tidal inundation at Lonnie's Pond, hydrologic inputs to the site include a stormwater pipe that drains into the northwest section of the pond, a cranberry bog that drains to the southwest, and a short herring run that links Pilgrim Lake with Lonnie's Pond. The groundwater flow is part of the Pleasant Bay Basin, within the Kescayogansett Pond, Lake and Stream sub-basins, and flows from west to east.

Bathymetry – Bathymetric conditions for Lonnie's Pond, based on NOAA nautical maps, indicates depths within the pond ranging from 4 feet (along shore) to thirteen feet (at the mouth to The River), with an average depth of about nine feet. Off of the river, the channel leading to Lonnie's Pond is only about three feet in depth.

Other water uses – In the fall of 2015, there were a number of moorings observed within the pond, but there appeared to be space to place a large square footage of FCW near the discharge of the stormwater pipe. Also, in a powerpoint presentation provided to the Orleans Water Quality Advisory Partnership by Stantec in October 2014, the pond was noted as "relatively uncrowded." There is a public boat dock on the western edge of the site. Shell fishing within the pond is open to family permits only.

Abutter interests/potential conflicts – The land use around Lonnie's Pond is residential. The area is not densely populated, and areas along the tidal channel (Kent's Point) that links the pond with the bay are protected by the Orleans Conservation Trust.

Acreage available within water bodies – The surface water area of Lonnie's Pond is approximately 14.5 acres.

Access points/easement requirements – The site has access via the public boat landing located on the western edge of the site, and is noted as accommodating up to six parking spots.

Land ownership – The land below the waters is held in Public Trust by the Town of Orleans. Private residences surround the Lonnie's Pond and private ownership of the land extends to the low tide water line. Per the public trust doctrine, the public has the right to certain uses (fish, fowling, navigation) between the mean low and mean high tide lines. Based on consultation with the Orleans Town Assessor, the land below the mean low tide line is likely owned by the Town of Orleans, although this should be confirmed through legal review.

(2) **Namequoit River** is an intertidal embayment located off of the lower section of The River, within the upper reaches of Pleasant Bay. Namequoit River in general is narrow and shallow. The 2006 MEP report estimates that existing nitrogen loads to the entire Namequoit River are 17.8 kg/day.

Water flow - In addition to the twice daily tidal inundation flowing from the lower reaches of The River, the primary hydrologic input to the site is from Arey's Pond (which ranges in depth from six to fourteen feet). The groundwater flow is part of the Pleasant Bay Basin, within the Namequoit River sub-basin, which flows from the southwest to the northeast.

Bathymetry – Bathymetric conditions for the Namequoit River, based on NOAA maps, indicate an average depth of one to two feet, but in some areas reaches four feet.

Other water uses – Docks and moorings line the shorelines of the Namequoit River and are privately owned. However, outside of the navigation channel, there appear to be small areas that are unused by dock, moorings and other boating activities. There is a boat yard located in Arey's Pond which appears to be heavily utilized and, therefore, there appears to be the potential for substantial boat traffic along the Namequoit River.

Abutter interests/potential conflicts – The land use around Namequoit River is largely low density residential with pockets of open space.

Acreage available within water bodies – The surface water area investigated for purposes of siting a FCW within Namequoit River is approximately 27 acres.

Access points/easement requirements – Access to Namequoit River would occur from Arey's Pond and would require a boat. The Town Landing at Arey's Pond is located off of Arey's Lane. No direct access to Namequoit River is available due to private land ownership along the water body.

Land ownership – The land below the waters is held in Public Trust by the Town of Orleans. Private residences surround the River and private ownership of the land extends to the low tide water line. Per the public trust doctrine, the public has the right to certain uses (fish, fowling, navigation) between the mean low and mean high tide lines. Based on consultation with the Orleans Town Assessor, the land below the mean low tide line is likely owned by the Town of Orleans, although this should be confirmed through legal review.

(3) **Paw Wah Pond** is a small, relatively deep, intertidal salt water pond located off of Little Pleasant Bay. The 2006 MEP report estimates that existing nitrogen loads to Paw Wah Pond are 5.6 kg/day.

Water flow – Paw Wah Pond receives twice daily tidal inundation from Little Pleasant Bay. Surface water flows from the surrounding residential areas into the low-lying pond. The Paw Wah groundwater sub-basin is located just south of the Namequoit River sub-basin, within the Pleasant Bay Basin, and flows similarly in a southwest to northeast direction.

Bathymetry – Bathymetric conditions for Paw Wah Pond, based on NOAA nautical maps, indicate an average depth of ten feet. The narrow channel from the bay to the pond appears to be about one foot in depth.

Other water uses – The Paw Wah Pond is noted as having little boat traffic, and did not appear to have many moorings when observed in the fall of 2015.

Abutter interests/potential conflicts – The land use around Paw Wah Pond is largely low density residential with pockets of open space. The Paw Wah Pond Conservation Area is an, undeveloped protected area located east of the pond.

Acreage available within water bodies – The surface water area within Paw Wah Pond is approximately 5.5 acres.

Access points/easement requirements – Access to Paw Wah Pond is available via a town owned parking area near the mouth of the pond, with limited parking.

Land ownership – The land below the waters is held in Public Trust by the Town of Orleans. Private residences surround Pah Wah Pond and private ownership of the land extends to the low tide water line. Per the public trust doctrine, the public has the right to certain uses (fish, fowling, navigation) between the mean low and mean high tide lines. Based on consultation with the Orleans Town Assessor, the land below the mean low tide line is likely owned by the Town of Orleans, although this should be confirmed through legal review.

(4) **Pochet Neck** is a narrow, shallow salt marsh dominated tidal sub-estuary located in the northeastern reaches of Pleasant Bay, just east of Pochet Island, Nauset Beach and the Atlantic Ocean. The 2006 MEP report estimates that existing nitrogen loads to the entire Pochet Neck bay are 9.4 kg/day.

Water flow – Pochet Neck receives twice daily tidal inundation from the upper reaches of Pleasant Bay via a very shallow channel. The Pochet Neck groundwater sub-basin is located within the Pleasant Bay Basin, and flows northeast to southwest.

Bathymetry – Bathymetry data from NOAA indicates that this estuary is generally shallow; at mean low tide, the depth at the inlet is two feet. However, there are small areas that are slightly deeper, ranging from four to ten feet in pockets.

Other water uses – Pochet has relatively little boat traffic, primarily due to the shallow navigation channels.

Abutter interests/potential conflicts – The land surrounding Pochet is residential, and includes a private island. The site is also contained with the boundary of the Cape Cod National Seashore.

Acreage available within water bodies – Pochet Neck has a waterbody surface area of approximately 140 acres, but the area investigated for purposes of siting a FCW is approximately 17 acres.

Access points/easement requirements – Access to Pochet Neck would require a boat, and would have to occur during high tides.

Land ownership – The area is surrounded by privately owned residences. The site is located within the boundaries of the Cape Cod National Seashore, and a demonstration project would require the approval of the National Park Service. Per the public trust doctrine, the public has the right to certain uses (fish, fowling, navigation) between the mean low and mean high tide lines. Based on consultation with the Orleans Town Assessor, the land below the mean low tide line is likely owned by the Town of Orleans, although this should be confirmed through legal review.

(5) Quanset Pond is a small enclosed intertidal basin located in the southern reaches of Pleasant Bay. The 2006 MEP report estimates that existing nitrogen loads to Quanset Pond are 7.9 kg/day.

Water flow – Quanset Pond receives twice daily tidal inundation from the lower reaches of Pleasant Bay via a short channel. The Quanset Pond groundwater sub-basin is located within the Pleasant Bay Basin, and flows northwest to southeast.

Bathymetry – Bathymetry data from NOAA indicates that the small pond is approximately three to seven feet in depth.

Other water uses – Quanset Pond has relatively few boat moorings and little boating activity.

Abutter interests/potential conflicts – The land surrounding Quanset Pond is largely residential.

Acreage available within water bodies – Quanset Pond's surface water area is approximately 7 acres in size.

Access points/easement requirements – Access to Quanset Pond is available via parking areas off of Quanset Road and Oyster Lane, and pathways around the pond. There is also a Town Landing located off of Quanset Road further off site, with eight spaces available for parking.

Land ownership – The land below the waters is held in Public Trust by the Town of Orleans. Private residences surround Quanset Pond and private ownership of the land extends to the low tide water line. Per the public trust doctrine, the public has the right to certain uses (fish, fowling, navigation) between the mean low and mean high tide lines. Based on consultation with the Orleans Town Assessor, the land below the mean low tide line is likely owned by the Town of Orleans, although this should be confirmed through legal review.

4. 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 are defined below.

a. Site Evaluation and Screening Criteria

(1) Site Suitability Criteria

Use Conflicts: The FCW demonstration project will need to cover a certain percentage of surface water area such that the FCW is sizable enough to generate a measurable difference in water quality within the intertidal waterbody. The required percentage is not known but it is assumed that the minimum would be 10% coverage by the FCW project, as previous studies have determined that increased coverage leads to more effective nitrogen reduction rates (Winston 2012). This criterion rates whether or not there is enough open water surface area, given other uses of the waterbody, so that the FCW project will not impede other activities that occur at the site.

Utility Infrastructure Conflicts: The FCW demonstration project cannot impact or in any way impede on existing utility infrastructure. This criterion rates the potential impacts or conflicts a demonstration project might have with existing utility infrastructure.

Utility Infrastructure Benefits: The FCW demonstration project may benefit from the proximity of existing infrastructure. For example, the existence of a stormwater discharge pipe may provide a distinct source of nitrogen input to the system, allowing for more effective monitoring. Therefore, this criterion rates the potential benefits of existing utility infrastructure n proximity to a demonstration project.

Ease of Access: This criterion rates the ease with which demonstration site locations can be accessed for installation/construction, operation and maintenance.

Land Ownership: This criterion rates whether or not the ownership of the site will impede the project being accepted and implemented.

Depth of Surface Water: The deployment of the FCW typically requires only a six inch draft and so can be deployed in areas where mean low water is only one to two feet in depth. However, it is important that the water depth is never so low that the FCW impacts the benthic environment. It is also important that the water depth not be too great, so that water quality differences on the leeward and windward sides of the FCW are measurable, i.e. hydrologic mixing of the water is slowed due to the presence of the FCW. Therefore, this criterion rates the site based on presences of an optimal depth at mean low water from two to four feet.

Overall Likelihood of Monitoring Plan to Yield Quantified Results: To be able to measure water quality differences created by the installation of the FCW demonstration project, a site needs to be configured in a way that allows for some control of the hydrologic inputs and outputs of the site, which is challenging within a tidal waterbody characterized by complex hydrologic processes. This criterion rates the configuration of each site and likelihood that the demonstration project can be constructed in such a way that measurable results are able to be quantified.

Regulatory Criteria/Permitability: This criterion ranks the likelihood that the demonstration project will receive regulatory approval.

(2) Other Overriding Considerations

Additional considerations include the aesthetics of the FCW on the local surroundings and overall community buy in on 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.

5. 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.

a. **Weighting of Individual Criteria -** It was determined by the team that no one criterion was most important than another, and therefore, each criterion was assigned equal weight.

b. **Results of Each Site Rating -** 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.

6. 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 for the potential site to implement the FCW demonstration project 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 other sites are all suitable for purposes of siting a FCW system; however, their site properties would make it relatively more difficult to monitor and measure the changes in water quality required for this demonstration project.

Quanset Pond and Paw Wah Pond are similar to Lonnie's Pond in many ways, but in general these two sites have a relatively smaller surface area. It is likely that, due to the other uses of the ponds, the FCW would also be relatively smaller than one placed in Lonnie's Pond, and therefore the resultant water quality changes would be more difficult to measure. In addition, the depth of Paw Wah Pond would make it more difficult to monitor changes as well.

Namequoit River and Pochet Neck are much more open systems, hydrologically, and would also present additional challenges when trying to measure water quality differences due to the placement of the FCW.

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ATTACHMENT H

TECHNICAL MEMORANDUM – FINAL WORK PLAN FOR FLOATING CONSTRUCTED WETLANDS

AECOM
9 Jonathan Bourne Drive
Pocasset, MA 02559
www.aecom.com

508.833.6950 tel
508.833.6951 fax

Memorandum

To	George Meservey, Director of Planning & Community Development Michael Domenica, PE, Program Manager
CC	Betsy Shreve, AICP, AECOM Project Director Terry Doss, Biohabitats Inc. Pete Munoz, Biohabitats Inc. Jennifer Doyle-Breen, AECOM Paula Winchell, AECOM
Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 3 - NT Demonstration Projects** **Deliverable 3.a.2 – Final Work Plan for Floating Constructed Wetland**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	May 25, 2016

1. Introduction

a. Purpose of FCW Demonstration Project

Floating Constructed Wetlands (FCW) are one of the non-traditional tools being tested by the Town of Orleans to determine the efficacy in managing nitrogen within the Town's water resources. Orleans' water resources have been degraded due to nutrient enrichment, primarily from the onsite dispersal of septic tank effluent (wastewater). 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 transformation and removal, as well as, potentially provide other ecosystem services such as wave attenuation, habitat and food structure and refugia for fish and nekton.

The goal of this demonstration project is to evaluate the potential to use FCWs to:

- Reduce nutrients;
- Realize associated ecological and socioeconomic benefits;
- Evaluate uncertainties associated with the local climate and environmental conditions;
- Assess local water quality and ecological benefits; and,
- Provide a case study to guide future projects.

The pilot project will be built as a temporary structure and will be monitored throughout the life of the project. If necessary, the structure can be removed at any time during the project or after the monitoring period is complete. However, if deemed appropriate, the FCWs could remain in place and continue to provide benefits after the demonstration project is complete.

The immediate objectives of the proposed FCW demonstration project are to:

- Install temporary floating wetlands;
- Monitor the performance of the floating wetlands to transform and reduce nitrogen in the surface water of the study area; and,
- Infer quantitative decisions about the value of FCWs at meeting the long term goals of the Town of Orleans in reducing nitrogen in its water resources.

b. Purpose of FCW Work Plan

The FCW Work Plan 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.

The purpose of the FCW work plan is to provide to the Town available information about FCW's to aid in the decision making process about whether or not to undertake the next steps towards the implementation of a demonstration project.

2. Background

a. Recommended Site Location

A series of meetings, reviews and surveys were held to determine appropriate sites for a potential FCW demonstration project, and then to condense the list to a final list of five potential sites: Lonnie's Pond, Namequoit River, Paw Wah Pond, Pochet Neck and Quanset Pond.

Of these five sites, Lonnie's Pond was found to be the most suitable for purposes of a demonstration project primarily because the site's configuration is the most likely to result in meaningful monitoring results. Specific site characteristics that would aid in monitoring success include the ease of access, the distinctive hydrological inputs and outputs, the overall shallow pond depths, and the potential lack of user conflict.

The four other final sites are also likely 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.

b. FCW Attributes

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 microorganisms and invertebrates. Under appropriate conditions, it has been shown that as water passes through the FCW, plant roots, bacterial activity and chemical/physical processes can reduce nitrogen levels as well as phosphorus, biological oxygen demand, total suspended solids and fecal coliform.

Under certain conditions, FCW have been shown to meet the following core design principals:

- Utilize natural, low-tech treatment technologies;
- Minimize energy use and mechanical system complexity; and,
- Incorporate educational and interpretive value into the system.

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, under certain conditions. The larger surface area created by the plant roots increases sedimentation, microbial decomposition, nitrification and denitrification, and alters water chemistry.

FCWs remove pollutants from the water column by four main processes: physical, biogeochemical, microbial and plant utilization. Denitrification by FCWs occurs by producing anoxic conditions through the restriction of oxygen diffusion into the water column and is the primary expected mode of nitrogen removal. Also, roots and plant litter act as sorption sites that develop biofilms which increase denitrification rates and thus nitrate removal rates. Plant uptake is only a small source of overall nitrogen removal.

c. Information Gaps to be addressed in Spring/Summer 2016 prior to full scale implementation.

To implement the FCW DP and allow for the most effective siting, the following additional data will need to be collected to supplement the initial site investigation:

- Benthic conditions of Lonnie's Pond, including sediment characterization;
- Site specific tide gage information, to understand the tidal range within Lonnie's Pond;
- Water elevation depths at mean low tide and lowest low tide across the pond;
- Hydrological conditions to determine the number of anchors required per unit; and
- Utility and infrastructure locations in and around Lonnie's Pond.

In addition, at the current time, the only known nitrogen removal rates for FCW's are from research conducted on FCWs located in freshwater bodies of water, typically water treatment ponds. There is limited research to date that captures nitrogen removal rates from FCWs located within estuarine bodies of water. Further information on nitrogen removal rates that can be attributed to FCWs in estuarine water bodies is needed.

3. Site Specific Assessment for Preliminary Design

a. Site Specific Conditions of Lonnie's Pond

As previously described, Lonnie's Pond was chosen as the most suitable site for purposes of the FCW demonstration project. The primary reasons that Lonnie's Pond was chosen include its easy access for construction and monitoring/maintenance purposes, the limited hydrological inputs to the pond which allow for more effective monitoring and its relatively shallow depths across the pond.

Also, Lonnie's Pond was regarded as likely having limited potential for conflicts given its relatively large surface water area, approximately 14.5 acres, and relatively low number of permitted moorings, which were reported by the Town of Orleans Harbormaster to be 37. In contrast, Arey's Pond, which is approximately 13 acres, has 86 moorings while Paw Wah Pond is approximately 5.5 acres and allows for 26 moorings.

Lonnie's Pond is an intertidal, salt water sub-embayment of the Pleasant Bay Estuary, located off of the upper section of The River. Lonnie's Pond is also part of the Pleasant Bay Estuary Area of Critical Environmental Concern. This sub-embayment receives freshwater discharge, primarily in the form of groundwater discharge or groundwater fed surface water flow, from the surrounding upland areas. The groundwater flow is part of the Pleasant Bay Basin watershed, within the Kescayogansett Pond, Lake and Stream subbasins, and flows from west to east. The surface water flow inputs to Lonnie's Pond include a cranberry bog discharge pipe that drains into the northwest section of the pond and a herring run that links Pilgrim Lake with Lonnie's Pond. These freshwater flows mix with incoming saltwater flows from twice daily tidal inundation that flow through a narrow channel from The River. The site discharges to the Pleasant Bay Estuary during the twice daily outgoing tides.

As a small, semi-enclosed hydrological system, the pond is at risk of eutrophication from high nitrogen loads entering the pond via direct groundwater seepage and surface water inflows. Potential impairments to the water quality of the pond include excess nutrients, low dissolved oxygen levels, high chlorophyll, excess macroalgae, and resultant degraded health of benthic fauna. The 2006 MEP report estimates that existing nitrogen loads are 4.3 kg/day.

The semi-enclosed nature of the system may allow for a more efficient monitoring program due to the confined hydrological inputs and outputs to the pond. One of the goals of the FCW demonstration project will be to show decreased nitrogen rates from water coming into contact with the FCW structures. Capturing these differences in a complex hydrological system with twice daily tidal exchanges will prove challenging. However, a small semi-enclosed pond with discrete inputs and outputs such as Lonnie's Pond will allow monitoring stations to be set upon either side of the FCW unit at the input and output areas to try to capture those differences.

Bathymetric conditions for Lonnie's Pond, based on NOAA nautical maps, indicates depths within the pond ranging from 4 feet (along the shoreline) to thirteen feet (at the mouth of the channel to The River), with an average depth of about nine feet. Off of the river, the channel leading to Lonnie's Pond is only about three feet in depth. General tide levels in the pond range from about five to six feet.

Salinity in Lonnie's Pond ranges from 29 – 31 ppt and surface water temperatures generally range from 21 – 24 degrees F (Alliance 2009, Cadmus Group 2015).

There is a public boat dock on the western edge of the site, which will allow for easy access via motorized boats and working kayaks for installation of the FCW units and for regular monitoring and maintenance activities. The public access ramp is noted as accommodating up to six parking spaces.

The land use around Lonnie's Pond is residential, and private ownership of the land extends to the low tide water line. The area is not densely populated, and areas along the tidal channel (Kent's Point) that link the pond with the bay are protected by the Orleans Conservation Trust.

The land below the waters, where the FCWs would be anchored, is held in Public Trust by the Town of Orleans. Per the public trust doctrine, the public has the right to certain uses (fish, fowling, and navigation) between the mean low and mean high tide lines. Based on consultation with the Orleans Town Assessor, the land below the mean low tide line is likely owned by the Town of Orleans, although this will be confirmed through legal review.

b. Describe any assumptions made about the site due to information gaps requiring confirmation

Due to winter conditions, certain site features could not be ascertained before the development of the preliminary concept, as described in the previous section (2.c). For purposes of this preliminary design, therefore, the following assumptions were made:

- The FCW could be anchored within Lonnie's Pond. This assumption is based on the number of moorings that already exist within the pond;
- The typical daily tides within the pond range from five to six feet. This is based on the MEP reports for Pleasant Bay and its subembayments;
- There is sufficient area to site the FCWs with a two to three foot water depth at mean low tide near the discharge areas for the stormwater pipe and the herring run;
- The preliminary siting locations for the FCWs in Lonnie's Pond will not affect or in any way disrupt existing utilities and infrastructure in and around Lonnie's Pond;
- There is enough water surface area within Lonnie's Pond to site FCWs that will utilize approximately ten percent of the surface water area within the pond so that there will be no disruption to the community and other users of the pond; and
- Wave energy is low within the areas of the pond in which the islands will be placed.

4. Preliminary Design

a. Site Configuration

To most effectively capture the nitrogen-laden surface water entering into Lonnie's Pond, it was determined that the FCW units should be located directly in front of the two distinct discharge areas: the drainage pipe located in the northwest section of the pond, just north of the public access ramp; and the herring run, located in the southwest section of the pond, south of the public access ramp. A preliminary site configuration, illustrating these concepts, is provided in Appendix A.

a. Project Components

- **Two floating modules,** each approximately 16,250 square feet in size, will be constructed to 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.

- **Anchoring** of the islands will be achieved by using helical embedment anchors driven into the seabed. The final type and number of anchors and mooring lines needed will be evaluated as the design progresses, but at the current time it is estimated for purposes of this work plan that four anchors and four mooring cables will be required per module. Helical anchors provide benefits including high pull strength, and easy installation and removal.

- **Mooring lines** for the islands will utilize a combination of galvanized steel cable and elastic mooring units. The combination will allow for continual tension of the mooring lines for minimal impact to the benthic environment, even at low tide, while also allowing the structure to move with the changing tides. Elastic mooring will also reduce floating island movement by keeping the island close to its constructed footprint while also dampening the movement of the individual units.

- The anchor, mooring and connection systems will be designed to resist forces approaching from all directions. The mooring and unit-to-unit connections are designed with redundancy to prevent the floating islands from becoming detached and free-floating around the pond. Each FCW unit will be secured to the seabed by one line and secured internally with redundant unit-to-unit connections.

- **Plant** type initially will be *Spartina alterniflora*, which will be obtained from local sources, as approved by the Town of Orleans. *S. alterniflora* was determined to be the most suitable for the initial planting due to its proven ability to quickly become established in the first growing season in salt waters. Plants will be placed on one-foot centers, for a total of approximately 4000 plants per unit. The roots of the *S. alterniflora* will grow from the surface through the porous matrix to the subaquatic environment, and will thus be available to the subaqueous community as habitat. After the first growing season, a diversity of plants suitable for saline water can be added to the islands at the beginning of the next growing season.

- **Waterfowl fencing** will be placed around each unit to deter use of the mats by waterfowl and shorebirds. Fencing will include posts along the edges of the islands, and string and flagging attached to the posts that crisscross the islands. The waterfowl fencing will be removed after the first growing season.

b. Sequencing of Subtasks

To achieve a full growing season and the most efficient use of the FCWs, the FCW units should be installed in early May and planted at that time. The FCW units can be installed and planted at any time of the year, but full growth of the plants and their root systems can best be achieved by planting in the spring.

Alignment of the islands by the inputs will be perpendicular to the shoreline, and will be based on a two-three foot depth at mean low tide to achieve the proper vertical depth above the benthic environment.

To deploy the islands, the following tasks will be undertaken:

- Manufacturing of the modules off site;

- Delivery of the modules, anchors, mooring lines and plants to the project site;

- Planting of the modules;

- Placement of anchors and mooring lines; and

- Towing units to anchors and mooring.

c. Labor resources needed to install the FCW DP

Construction activities will be managed to limit disturbance to the residential community, lake access and recreational activities. Onsite activities will include receiving manufactured wetland modules, planting, anchoring and placement. A boat will assist with island placement at the anchor/moor locations.

Specialized labor to deploy the anchors and mooring lines will be needed, and may include a team of divers and may also require specialized equipment to screw in the anchors. More information on benthic and hydrologic conditions will be required before this can be determined.

Four to six laborers will be needed to unload the modules, plant the modules, set the anchors and mooring lines, and then tow the modules to the anchors and mooring lines for hookup.

d. Issues considered during preliminary design:

- In-situ versus laboratory monitoring of nitrogen removal;
- Lower DO in area around FCW;
- Excessive organic loadings from detritus;
- Concentrations of metals or other contaminants;
- Attraction of waterfowl that could add to the loadings;
- Invasion by weeds from islands;
- Long-term buoyancy; and
- Overall durability.

5. Monitoring and Maintenance

The specific objective of this study is to evaluate the effectiveness of an array of FCWs 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 nitrogen removal data that will be collected from other existing estuarine floating wetlands in Baltimore Harbor and, if available, from other natural marshes that can provide reference conditions and an understanding of relative performance. Additionally, small round samples of FCW material "pucks" will be attached to the undersides of the FCW. A determination of the nitrogen uptake rates by the epiphyte biofilm community in a controlled lab setting will be made. A calculation of the combination of the macrophyte biomass and epiphyte biofilm nutrient absorption and uptake also will be made.

a. In-Situ Water Quality Analysis

Water quality will be sampled in three ways: using continuous dataloggers; using a hand-held probe to collect discrete readings; and using grab samples that are then sent to a lab for analysis.

Dataloggers: Water quality data will be collected throughout the growing season in fifteen minute intervals using YSI 6600V2 continuous data sondes. Continuous water quality parameters will include temperature, DO, turbidity, chlorophyll and salinity. The sondes will be deployed on either side (landward and seaward) of the FCW systems, for a total of four sondes. The data will be collected to determine if there are measurable water quality differences on either side of the FCWs.

Discrete and Grab Samples: Discrete water quality measurements and grab samples will be taken at weekly intervals during the growing season (April 15 through September 30).

Discrete onsite water quality parameters will be measured using a hand-held YSI 556 MPS probe, and will be taken on the landward and seaward sides at each of the FCWs at the same level in the water column during each monitoring event for the following parameters: temperature, conductivity, salinity, DO, and pH.

Paired grab samples will be taken on the landward and seaward sides at each of the FCW systems at the same level in the water column during each monitoring event, and will then be sent to a qualified lab for analysis of the following constituents: N02 and N03, total N, total P, TKN, TSS, NH4 and chlorophyll a.

b. Lab Analysis

Aboveground biomass of vegetation on the FCW will be harvested at the end of the growing season after a full year of establishment. Plant biomass will be air-dried and sub-sampled. These sub-samples will be oven-dried at 70 degrees C for 24 hours and weighed. Additional sub-samples will be combined in an ashing oven in the lab to determine the ash-free dry weight. The data will be used to determine the dry weight aboveground biomass and, combined with seasonal diurnal curve measurements, an estimate of the net primary production of the wetland in relation to overall community metabolism. Carbon, nitrogen and phosphorus along with micronutrients in the biomass will be assessed by using standard methods to evaluate nutrient uptake performance. Thus, total mass of nutrients in the aboveground biomass will be estimated by multiplying nutrient content percentage by the biomass.

Biofilm uptake analysis will be employed by deploying an array of pucks made of the same FCW material, approximately 100mm in diameter and 15mm thick weighing on average 3.5 to 4.0 grams. Six pucks for each FCW will be constructed and evenly spaced and attached to the unit. Each floating wetland will have one rack attached. A similar number of racks will be attached to nearby docks and/or floats as control conditions. Seasonally, a rack will be randomly selected from one FCW and one control site with two pucks randomly selected from each for analysis of biofilm establishment and colonization by invertebrates.

c. Maintenance Requirements

Visual inspection of the FCWs will occur on a monthly basis. The main purpose of the maintenance inspections will be to confirm that the project integrity is maintained and to document any changes to the units, the plants or the surrounding area. Maintenance activities will include the following:

- Inspection to confirm integrity of all submerged hardware and anchoring, and above water tethering and waterfowl fencing;
- Health and number of plants, and replanting where necessary;
- Removal of man-made and natural debris; and
- Periodic inspection for signs of degradation of base material, mechanical (tearing), waterfowl use, or UV damage (discoloration).

6. Project Cost Estimate

A cost estimate for the FCWs was estimated and is provided in Appendix B. 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.

7. Regulatory Considerations

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 Massachusetts 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 Massachusetts 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.

Installation of the FCW Demonstration Project would require either a Request for Determination of Applicability (RDA) or a Notice of Intent filing with the Orleans Conservation Commission. It is recommended that consultation with the Commission occur to determine the appropriate application mechanism.

The Chapter 91 regulations allow the placement of temporary moorings, floats and rafts may be allowed through an annual permit issued by the Orleans harbormaster; it is anticipated that this authorization process could be allow for the installation of the temporary FCW islands, although further consultation with the harbormaster is required in regard to this review and approval process. The installation of temporary moorings are allowed as a non-reporting activity by both the USACE and MassDEP under the General Permits for Massachusetts; therefore applications under Sections 404 and 401 of the Clean Water Act are not anticipated to be necessary.

A MEPA filing for the update to Orleans Wastewater Management Plan is envisioned, and should include the FCW Demonstration Project. Consultation with Massachusetts NHESP is also recommended to confirm that the FCW Demonstration Project would be outside of Massachusetts NHESP Priority Habitat Areas.

8. Potential Funding Sources

Deliverables developed under Task 5 include an evaluation of general funding mechanisms for the overall wastewater management project, including options such as SRF funding, MassDEP 604b/319 grants, and USDA rural development grants.

In addition to the funding sources discussed as part of Task 5, potential funding sources available specifically for constructed wetlands were researched. Availability of these funding sources would be dependent on a successful application process, and also on application submittal deadlines as compared to the FCW DP schedule. Deadlines for many grants have passed or are imminent for the current calendar year, although submitting an application for a 2017 project might be feasible.

The potential funding sources and websites with additional information on each funding opportunity are listed in Table 1.

Table 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.

9. Projected Full Scale Approach

If FCW were implemented as part of the full scale Non-Traditional project, it is anticipated that there would be additional FCWs installed at some or all of the other sites identified in Pleasant Bay, including Namequoit River, Paw Wah Pond, Pochet Neck and Quanset Pond. No potential sites have been identified for either the Town Brook or Rock Harbor watersheds, so it is not anticipated that full-scale implementation would include FCWs in these watersheds.

As indicated above, a number of regulatory approvals are required for the FCW DP and it is anticipated that similar approvals would be required for full-scale implementation. In addition, it is anticipated that MassDEP would issue a watershed permit approving the full-scale implementation. Details of the watershed permit and any conditions to be included therein are unknown at this time; however, full-scale implementation would be required to in accordance with the conditions of the watershed permit. Full scale implementation is also contingent upon monitoring results that demonstrate favorable nitrogen removal.

10. Summary and Next Steps

Technologies that could be co-located with the floating wetlands to improve overall nitrogen removal rates:

- Some type of solar-powered aeration located on the wetlands to boost DO levels in the root zones;
- Additional media at the floating wetlands (geotextile perhaps, cut in strips – kelp style) to maximize surface area for attached growth; and,
- Some additional DO boosting elsewhere in pond – either combining with more active microbial zones in edge wetlands with compressor powered small bubble aeration in gravel beds, or floating windmills.

These alternative adaptations proposed for the FCW utilize the lake restorer developed by John Todd (Todd 1996) and further demonstrated by others (Yaron et al. 2000, Kangas 2004) as a modification of the "living machine" concept. This would allow the FCW to actively pump and recirculate water through the system, optimizing each step in the treatment process in a manner similar to that of a treatment wetland. Specialized nitrification and denitrification conditions and mechanisms in the treatment train may provide higher nitrogen removal rate performance in creating N_2 gas dissipating from the lagoon system.

The next step recommended before implementation of the FCW DP 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.

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.

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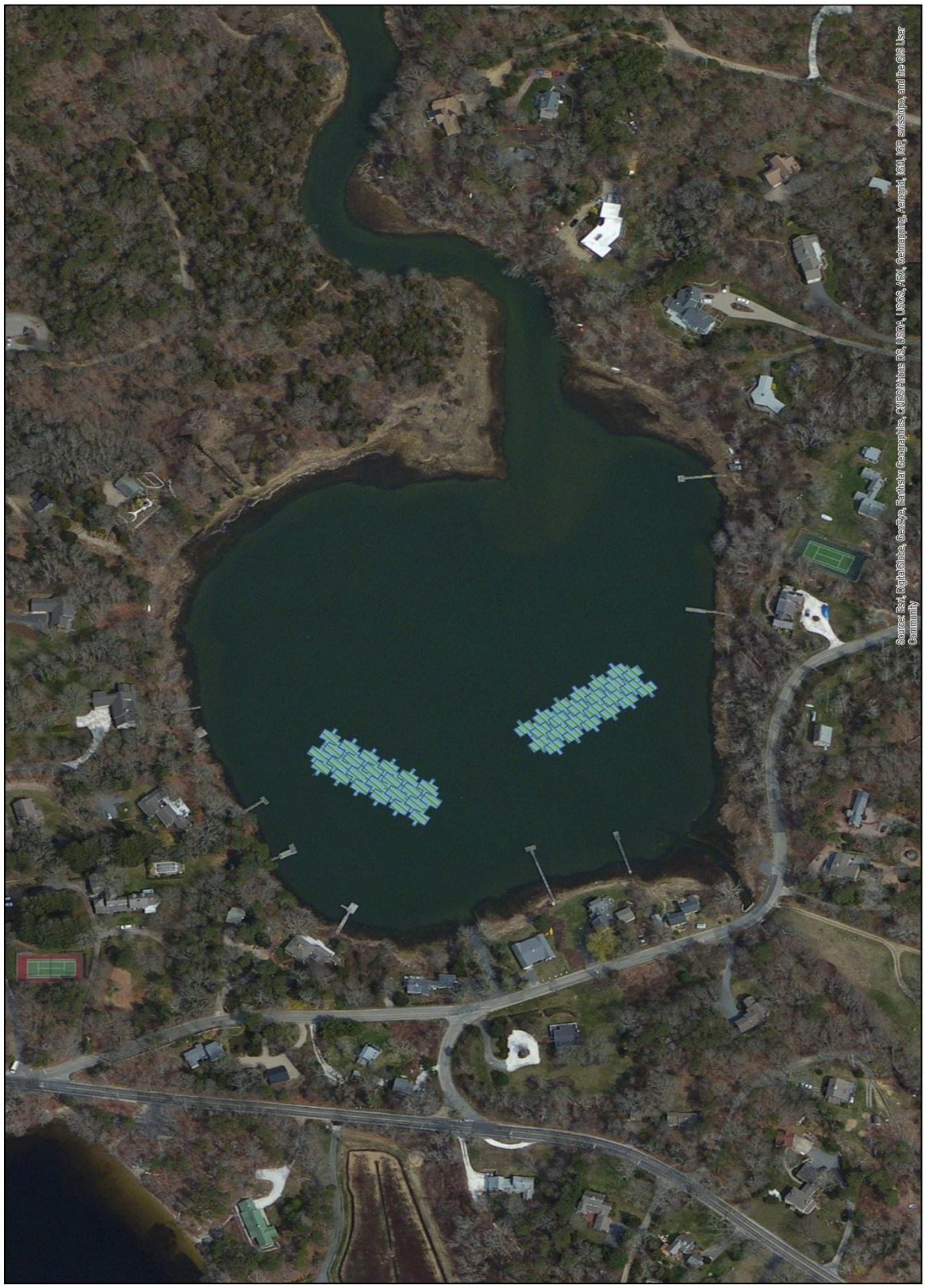
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Appendix A

Preliminary Demonstration Site Configuration – Lonnies Pond


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
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Appendix B

Demonstration Project Cost Estimate – Lonnies Pond

Town of Orleans, MA
FY 2016 Water Quality and Wastewater Planning
Estimated Capital Costs
Floating Constructed Wetlands - Demonstration 2 - Lonnie's Pond

Components	Quantity	Unit	Unit Cost	Extended Total	Remarks/Notes
Mobilization and Demobilization	1	LS	$ 51,410	$ 51,400	5% of Other Items
FCW Module - Manufacturing and Shipping	32,500	Ea.	$ 22	$ 715,000	As quoted by Floating Wetland Solutions, February 2016
FCW Module - Installation	1	Ea.	$ 113,000	$ 113,000	As quoted by Floating Wetland Solutions, February 2016
Anchors & Mooring Ropes - Purchase and Shipping	8	Ea.	$ 1,250	$ 10,000	Assumes four anchors & ropes per island, 2 islands
Anchor & Mooring Ropes - Install	8	Ea.	$ 90	$ 700	Based on labor provided for NYC project, August 2015
Plants - purchase and shipping	32,500	Ea.	$ 3	$ 97,500	Assumes local nursery with multiple shipping
Plants - staging and install	32,500	Ea.	$ 2	$ 65,000	2" plugs (one per sq. ft.)
Freight	1	Allow.	$ 25,000	$ 25,000	10 truckloads
Waterfowl Fencing	2	L.F.	$ 1,000	$ 2,000	Assumes stringing and plastic fencing for 16,250 lf/island
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	FCW Demo based on 0.7 Acre.
		Subtotal		$ 1,079,600	
		Overhead and Profit	0.0%	$ -	OH&P Included in above Unit Prices
		Subtotal		$ 1,079,600	
		Contingency	25.0%	$ 269,900	
		Construction Total		$ 1,349,500	
		Town Administration and Engineering			
		Town Administration	5.0%	$ 67,500	
		Engineering - Planning/Consultation	5.0%	$ 67,500	
		Engineering - Design	10.0%	$ 135,000	
		Engineering - Construction	15.0%	$ 202,400	
		Total Estimated Project Cost		**$ 1,821,900**	Engineering News Record (ENR) = 10182 (Feb. 2016)

Town of Orleans, MA
FY 2016 Water Quality and Wastewater Planning
Estimated Annual Operation and Maintenance Costs
Floating Constructed Wetlands - Demonstration 2 - Lonnie's Pond

Components	Quantity	Unit	Unit Cost	Extended Total	Remarks/Notes
Seasonal Site Review and Maintenance	2	Ea.	$ 6,000	$ 12,000	Annual Cost - to occur each spring and fall
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
		Subtotal		$ 12,000	
		Contingency	10.0%	$ 1,200	
		Subtotal		$ 13,200	
		Town Administration and Engineering			
		Town Administration	3.0%	$ 400	
		Engineering - Planning/Consultation	0.0%	$ -	
		Engineering - Design	0.0%	$ -	
		Engineering - Construction	0.0%	$ -	
		Total Estimated Annual Operation and Maintenance Costs		**$ 13,600**	Engineering News Record (ENR) = 10182 (Feb. 2016)

Town of Orleans, MA
FY 2016 Water Quality and Wastewater Planning
Estimated Replacement Costs
Floating Constructed Wetlands - Demonstration 2 - Lonnie's Pond

Components	Quantity	Unit	Unit Cost	Extended Total	Remarks/Notes
Mobilization and Demobilization	1	LS	$ 595	$ 600	5% of Other Items
Plantings	1,625	Ea.	$ 3	$ 4,900	5% of Initial Plantings
Site review and replanting	1	L.S.	$ 6,000	$ 6,000	
Waterfowl Fencing	1	Ea.	$ 1,000	$ 1,000	
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
		Subtotal		$ 12,500	
		Overhead and Profit	22.0%	$ 2,800	
		Subtotal		$ 15,300	
		Contingency	25.0%	$ 3,800	
		Construction Total		$ 19,100	
	Town Administration and Engineering				
		Town Administration	3.0%	$ 600	
		Engineering - Planning/Consultation	0.0%	$ -	
		Engineering - Design	10.0%	$ 1,900	
		Engineering - Construction	15.0%	$ 2,900	
	Total Estimated Replacement Cost			**$ 24,500**	Engineering News Record (ENR) = 10182 (Feb. 2016)

Town of Orleans, MA
FY 2016 Water Quality and Wastewater Planning
Estimated Annual Monitoring Costs
Floating Constructed Wetlands - Demonstration 2 - Lonnie's Pond

Components	Quantity	Unit	Unit Cost	Extended Total	Remarks/Notes
Monthly Field Visits	12	Ea.	$ 3,200	$ 38,400	Assume 2 people, $100/hour, two 8-hour days
Water Quality Samples	48	Ea.	$ 450	$ 21,600	Assumes 4 samples each month
Dataloggers	4	Ea.	$ 8,000	$ 32,000	Assumes one on each side of 2 islands
Download & Analysis of Dataloggers	-	Ea.	$ -	$ -	
Biomass Sampling & Analysis	1	Ea.	$ 15,000	$ 15,000	Based on sampling performed for Baltimore Harbor
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
	-		$ -	$ -	
		Subtotal		$ 107,000	
		Contingency	10.0%	$ 10,700	
		Subtotal		$ 117,700	
	Town Administration and Engineering				
		Town Administration	5.0%	$ 5,900	
		Engineering - Planning/Consultation	3.0%	$ 3,500	
		Engineering - Design	0.0%	$ -	
		Engineering - Construction	0.0%	$ -	
	Total Estimated Annual Monitoring Costs			**$ 127,100**	Engineering News Record (ENR) = 10182 (Feb. 2016)

ATTACHMENT I

TECHNICAL MEMORANDUM – SITE CHARACTERIZATION AND EVALUATION FOR AQUACULTURE AND SHELLFISH PROPAGATION

AECOM
9 Jonathan Bourne Drive
Pocasset, MA 02559
www.aecom.com

508.833.6950 tel
508.833.6951 fax

Memorandum

To	George Meservey, Director of Planning & Community Development Michael Domenica, PE, Program Manager
CC	Betsy Shreve, AICP, AECOM Project Director Sia Karplus, Science Wares, Inc. Anamarija Frankić, PhD, University of Massachusetts Boston, Green Harbors Project Mark Begley, MT Environmental Restoration Paula Winchell, AECOM
Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 3.b – NT Demonstration Projects** **Technical Memorandum on Final Site Characterization and Evaluation for Aquaculture/Shellfish Propagation (evaluation criteria and ranking)**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	03/13/16

1. Background

a. Purpose

The Final Site Characterization and Evaluation Technical Memorandum presents the process used to identify, evaluate, rank and ultimately recommend specific shellfish demonstration sites. This Memorandum including the following:

- 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; and
- Recommended demonstration sites paired with specific shellfish propagation approaches (such as bottom planting hard shell clam, oyster beds or oyster aquaculture), and rationale for selection.
- Comments received as part of review of the Draft Site Characterization and Evaluation Technical Memorandum, and AECOM Shellfish Team responses (Appendix A).

In addition, key terms are defined including the categories of data that were evaluated. The site selection criteria and ranking system used to assess potential demonstration sites are also explained.

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. At this stage, the team is ranking sites where a demonstration could be practically implemented. This siting evaluation is documented in this first Technical Memorandum and 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 Site Characterization Technical Memorandum, and the team's responses are also part of the evaluation process used to identify locations for shellfish demonstration projects.

Once the specific locations for demonstrations are selected, the next step will be to define the specific design parameters for each demonstration project site, including numerical targets for shellfish and nitrogen-removal. This detailed design and engineering will be presented in the next Technical Memorandum, entitled "Preliminary Engineering Design and Work Plan" and will contain a detailed monitoring plan for water quality as well as shellfish biomass, predators and diseases.

b. Definition of Aquaculture and Coastal Habitat Restoration (CHR)

In order to establish a consistent meaning of aquaculture and CHR in the context of this Technical Memorandum, these terms are defined as follows:

Aquaculture: the farming of shellfish in controlled or selected marine environments as single, unattached units, for eventual harvest. Farming involves using gear such as cages, floating bags or trays. Direct planting of shellfish on the sea floor after a period of growing in gear is also considered aquaculture. Marine aquaculture is usually located in bodies of saltwater, with land-based, manmade systems such as upweller tanks used for certain initial phases of growth.

Shellfish farming typically includes activities that seek to enhance production, including:

- Moving or splitting populations of shellfish to control density within gear;
- Locating shellfish in specific regions of the water column with better growing conditions; and
- Protecting from predation.

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 the purpose of this Technical Memorandum 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.

Coastal Habitat Restoration (CHR): creating or rehabilitating native shellfish habitats; creating an ecosystem that includes a combination of shellfish species and associated organisms and plants that remove nitrogen from the water column. Establishing new shellfish areas and bed systems where native shellfish species have not existed historically is also considered CHR. Dense populations of oysters are often referred to as oyster bottoms, oyster beds, oyster bars, oyster banks, or oyster reefs. These terms refer to large colonial aggregations of living oysters and oyster shells that provide habitat for other species. Quahog bottom planting is also CHR, as propagation restores native shellfish populations, habitats and improves bottom sediment. Nitrogen-removal calculations are based on average shellfish uptake as demonstrated in published literature as well as through personal experience by the assembled Team.

Growing options include (1) bottom planting of shellfish raised from seed through hatcheries and propagation programs, (2) growing spat-on-shell (remote set) in trays or bags, and (3) bed establishment programs by means of substrate enhancement (cultch placement). CHR may also involve establishing and/or enhancing estuary salt marshes and eelgrass beds as part of an effort to create suitable coastal habitats.

Oyster Beds can be established both for harvest as well as for "no take" sanctuaries. Both contribute important ecosystems services, including:

- Nitrogen uptake;
- Improved sediment quality;
- Increased biological diversity; and
- Shoreline protection from erosion and storms.

The distinction is that "no take" sanctuaries are beds where removal of oysters for harvest is prohibited for a period of 5 years or more, to enable the bed structure to be established without the inevitable disturbances from harvest activities. No take areas also enable oysters to continue to grow after they have reached harvest size. These more mature shellfish are expected to produce larger spawns. In addition, allowing oysters to grow and spawn for several generations is expected to promote a more disease resistant population. Spawning sanctuaries are believed to increase native populations and thus support commercial and recreational harvest more than beds that are continuously harvested (Frankic et al, 2015; Frankic and Cataldo, 2007; Jones, 2006).

2. Introduction

a. Consensus Plan Description

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 of Orleans. The panel consisted 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 starting in July 2014, 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. Initially, a Hybrid Plan was designed that included specific sites for aquaculture and coastal habitat restoration (CHR), as well as permeable reactive barriers (PRB) and floating constructed wetlands (FCW). The number of acres of shellfish growing area (as well as linear feet of PRBs and square footage for FCW) were quantified to achieve specific nitrogen-removal targets. This exercise was undertaken to ensure that the quantities of shellfish (and all other non-traditional technologies) proposed in the Consensus Plan were feasible to install. These specific locations became the basis for potential demonstration site locations for aquaculture and CHR, as well as FCWs and PRBs.

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 shellfish and other 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 growing locations, but instead focus on overall area of shellfish and other alternative technologies needed to remove the appropriate mass of nitrogen at the watershed level.

The resulting map (Figure. 1), entitled Conceptual Approach to Meet Orleans Water Quality Goals (March 2015) shows the agreed upon water quality management plan and includes 5.5 acres of shellfish in the Nauset Harbor watershed and 9 acres of shellfish in Pleasant Bay. Neither coastal habitat restoration nor aquaculture is part of the plan for the Rock Harbor watershed. This map also specifies acreages for FCW and linear feet of PRBs.

b. Initial Process of Site Identification

As part of updating the 208 Plan, The Cape Cod Commission (CCC) created Traditional and Non-Traditional Scenarios that would meet the regulatory requirements for nitrogen formalized as Total Maximum Daily Loads (TMDLs) for Orleans' impaired water bodies. The Traditional Scenario for Orleans used centralized sewers exclusively. The Non-Traditional Scenario met nitrogen-removal goals through a subset of the many alternatives that are described in the 208 Plan's Technology Matrix. The subset of technologies in the Commission's Non-Traditional Scenario included PRBs, FCWs, CHR, shellfish aquaculture, fertigation, composting and urine-diverting toilets and innovative/alternative septic systems. In order to ensure consistency with this established regulatory framework, the Non-Traditional Scenario developed by the Commission became the starting point for customizing a non-traditional bookend for the OWQAP and consensus-building process.

This planning and design process for tailoring a non-traditional bookend for Orleans included studying the information prepared by the CCC, and collecting and analyzing a significant amount of additional local data that was not reviewed as part of the regional planning process undertaken by the Commission. Local data from satellite images, GIS maps, groundwater maps, and coastal pond bathymetry data was reviewed. Paper records on the history of local aquaculture, and Town shellfish propagation were aggregated into a database for trending and other analyses. Site visits both by land and by water were conducted to validate locations for shellfish aquaculture and CHR. Interviews with the Orleans Shellfish Constable, the former Shellfish Constable, and local shellfishers were also conducted to verify initial findings.

Stantec

CONCEPTUAL APPROACH TO MEET ORLEANS WATER QUALITY GOALS

MARCH, 2015

TOWN OF ORLEANS
MASSACHUSETTS

N

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Feet

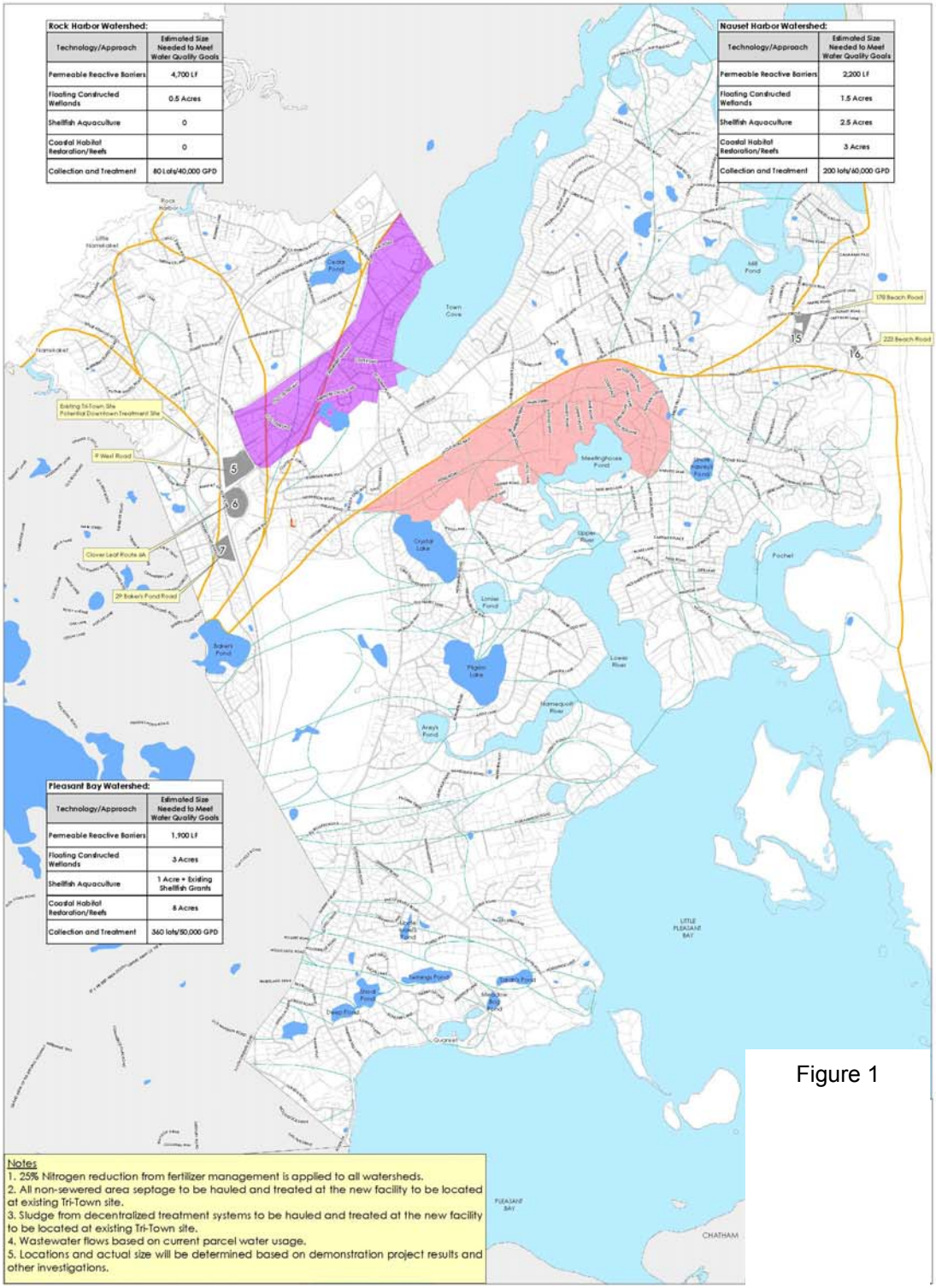


Figure 1

This local data was used to:

- Evaluate depth to groundwater and aquifer thickness for PRB installations;
- Assess roads and neighborhoods for PRB installations;
- Classify water bodies in terms of suitability for aquaculture and/or CHR based on water quality data contained in Massachusetts Estuaries Project (MEP) Reports and data synthesis from the Pleasant Bay Alliance;
- Inventory potential and existing use conflicts (boating, moorings, aesthetic preferences);
- Identify specific areas for shellfish growing within waterbody; and
- Recommend different species for specific areas, including quahogs, oysters, and mussels.

This local data collection and evaluation allowed the Non-Traditional Bookend for Orleans to be based on key validated site parameters, ensuring that the non-traditional technologies were feasible in their planned locations. In addition, a Technical Memorandum on Non-Traditional Technologies (Appendix B) was prepared and submitted to the OWQAP. This Technical Memorandum detailed initial performance expectations, as well as key site and permitting considerations that should be used to verify the usefulness of these technologies for specific subwatersheds in Orleans.

The results of this detailed analysis and resulting initial locations for non-traditional technologies were presented and thoroughly discussed during the October 8, 2014 OWQAP Stakeholder meeting. Based on this technical review, as well as direction from the OWQAP, specific non-traditional technologies were then selected to be used to create a "Hybrid Plan" that included both non-traditional as well as traditional technologies for Orleans. The Hybrid Plan showed both technologies in specific locations in order to verify that appropriate nutrient loads could be removed.

c. Hybrid Plan Site Identification Criteria used during OWQAP Process

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. Preliminary comparative costs were also presented on a relative dollars/kilogram of nitrogen removed basis. The Site Evaluation Matrix is included in Appendix C.

Ranked categories include:

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

- Overall cost

Based on these criteria, all sites shown on the Hybrid Plan for both shellfish aquaculture and CHR were retained. These locations became the initial list of possible locations for demonstration projects, needed to validate the feasibility and nutrient-removal capacity of shellfish in Orleans. The following sites and activities (aquaculture and/or CHR) were identified as part of the process of defining the Consensus Plan and are being reviewed in greater detail as part of this next phase of work, currently underway:

- Town Cove (both aquaculture and CHR);
- Mill Pond (both aquaculture and CHR);
- Little Pleasant Bay (both aquaculture and CHR);
- Arey's Pond (aquaculture);
- Pochet (CHR);
- Lower River (CHR); and
- Quanset Pond (CHR).

d. Current Process of Site Review and Validation

The initial shellfish sites, taken from the Hybrid Plan developed during the OWQAP process were further evaluated by the Shellfish Technical Team that was subcontracted by AECOM to evaluate demonstration sites and prepare this Technical Memorandum. 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 the first phase of planning;
- 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 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.

This Technical Memorandum reports on the findings of these tasks.

3. Description of Proposed Sites

a. Definitions: Data Parameters

There are two categories of data used to assess potential demonstration locations: (1) information on site ecology, which includes the environmental conditions in the water bodies where shellfish will be raised, and (2) information on the surrounding environment, which addresses land use characteristics, as well as public and private uses associated with the demonstration sites. The specific data parameters associated with each data category are:

Site Ecology

- Water quality data which includes salinity, dissolved oxygen (DO), chlorophyll a, total nitrogen (TN), dissolved organic nitrogen (DON), particulate organic matter (POM), pH, and temperature;
- Tide and water flow (circulation);
- Bathymetry;
- Benthic Conditions;
- Eelgrass bed locations; and
- Local knowledge of shellfish species, predation and shellfishing activities at these sites.

Surrounding Environment

- Type and location of current uses;
- Abutter interests/potential conflicts;
- Acreage available within water bodies;
- Access points/easement requirements;
- Land ownership; and
- Viability of using existing shellfish grants as a demonstration.

Each of these data parameters is defined or explained for use in site selection as follows:

Site Ecology Terms

- **Bathymetry:** a measure of water depth.
- **Benthic Conditions:** the type of sediment present at a given site, expressed as grain size.
- **Chlorophyll *a*:** a green pigment responsible for the absorption of light to provide energy for photosynthesis. Phaeophytin *a* is also a photosynthetic pigment, often produced by the degradation of chlorophyll *a*. Chlorophyll *a*, as well as total pigment concentration can be used as a proxy for food concentration.

- **Dissolved Oxygen:** The amount of elemental oxygen, O_2, in solution under existing atmospheric pressure and temperature. Low levels of dissolved oxygen (DO) can slow the growth rate and reduce the survival of shellfish (Gosling 2003; Whetstone et al 2005).

- **Eelgrass bed locations:** mapped areas where eelgrass is currently growing.

- **Total Nitrogen:** the combined sum of all organic and inorganic forms of nitrogen in a water sample. These forms of nitrogen can include nitrate, nitrite, ammonia, particulate organic nitrogen and dissolved organic nitrogen.

- **Dissolved Organic Nitrogen**: the soluble form of nitrogen contained in organic (carbon-based) compounds such as amino acids, peptides, humic substances and protein.

- **Local knowledge of shellfish species, predation and shellfishing:** information gathered from Orleans Shellfish Constable/Harbormaster (past and present), Assistant Harbormaster, and local shellfishers.

- **Particulate Organic Matter:** the non-soluble components that can be filtered out of a water sample.

- **pH:** an expression of the acid-base relationship designated as the logarithm of the reciprocal of the hydrogen-ion concentration. The value of 7.0 expresses neutral solutions; values decreasing below 7.0 represent increasingly acidic solutions; values increasing above 7.0 represent increasingly basic solutions.

- **Salinity:** concentration of sodium, potassium, magnesium, calcium, bicarbonate, carbonate, sulfate, and halides (chloride, fluoride, bromide) in water.

- **Turbidity:** the relative clarity of a liquid, determined by measuring the amount of light that is scattered by suspended particles in the water column. The presence of suspended or colloidal matter or planktonic organisms reduces light penetration and increases turbidity.

- **Tide and Water Flow:** refers to the circulation of water within a site; currents and tidal exchange can affect both food and oxygen availability, as well as larval dispersion, transport and fate (Brumbaugh et al 2005).

Surrounding Environment Terms

- **Type and location of current uses:** there are other activities that occur on or near the site, such as boating swimming, and wild shellfish harvesting, which could limit the ability to install a demonstration project.

- **Abutter interests/potential conflicts:** neighbors are less likely to object to a well-designed demonstration location near them.

- **Acreage available within water bodies:** acreage must be sufficient for a demonstration at the site.

- **Access points/easement requirements**: a convenient, public location is available from which to access the site for installation, operation, and maintenance of the demonstration.

- **Land ownership:** there are parcels owned privately that limit or preclude access to the site.

- **Viability of using existing shellfish grants as a demonstration**: there may be an advantage to working with current holders of shellfish grants in Little Pleasant Bay to implement a demonstration project.

b. Introduction to Site Descriptions

Review of Town Cove and Mill Pond for demonstration locations considered the entire waterbody. The Shellfish Technical team conducted a desktop analysis, land-based field assessment and water-based survey of Pleasant Bay and determined that no additional demonstrations sites needed to be evaluated. Seven (7) potential demonstration sites were evaluated based on site ecology and surrounding environment parameters. These sites, shown in Figure 2, include:

- Town Cove
- Mill Pond
- Little Pleasant Bay
- Arey's Pond
- Pochet
- Lower River
- Quanset Pond

Key site ecological factors assessed include food availability, salinity and temperature because they are the primary water quality determinants of quahog and oyster distribution and abundance (Menzel 1989; Gosling 2003). Dissolved oxygen (DO) is also a significant parameter, as low levels of DO can limit growth and survival. These constituents are considered threshold factors in assessing site suitability.

The major natural source of food in marine environments for filter feeding organisms such as shellfish is phytoplankton, or algae. Phytoplankton contain chlorophyll a, therefore concentrations of chlorophyll a reflect food availability. Phaeophytin a is also a pigment found in algae. Chlorophyll a data, and in some cases total pigment data (chlorophyll a + pheophytin a) is available for each site. Quahogs and oysters are tolerant of wide temperature ranges; because they enter a dormant phase when water temperatures are below 4°C/40°F, both can survive temperatures below 0°C. Both species also tolerate a wide range of salinity. However, predation has been observed to decrease at salinities that are lower than ocean water (approximately 35 ppt). The temperature is consistent for all sites. Salinity varies among sites with data presented within each site description. Field evidence demonstrates that both oysters and quahogs are viable at current temperatures and salinities. All of the potential demonstration sites experience low DO concentrations at the bottom of the water column. These data are presented for each site within the site descriptions in Section 3.c.

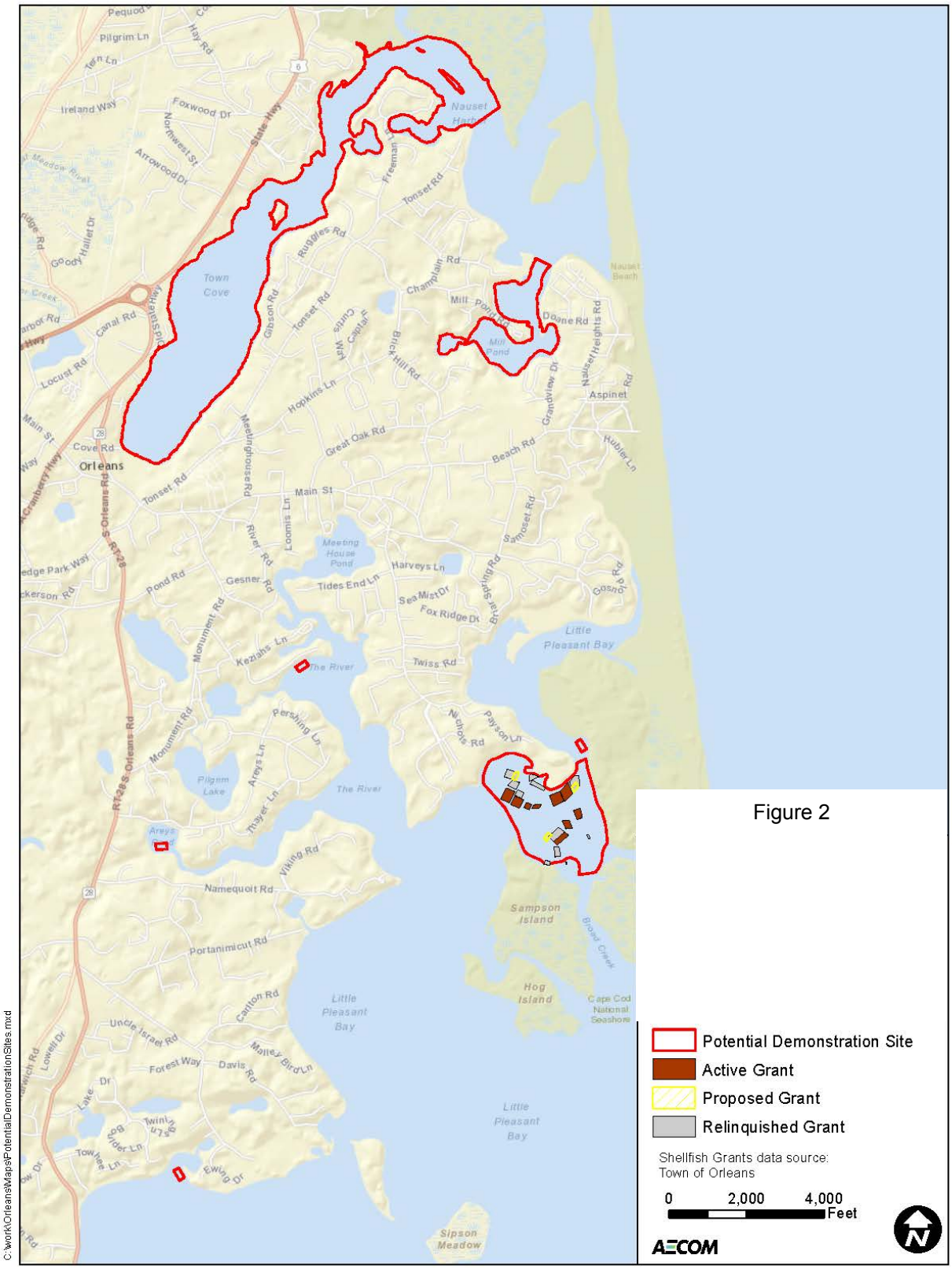

Potential Demonstration Site
Active Grant
Proposed Grant
Relinquished Grant
Shellfish Grants data source:
Town of Orleans
0
2,000
4,000
Feet
AECOM
C:\work\OrleansMaps\PotentialDemonstrationSites.mxd
Orleans
Town Cove
Little Pleasant Bay
The River
Pilgrim Lake
Meeting House Pond
Mill Pond
Sampson Island
Hog Island
Sipson Meadow
Nauset Beach
Aspinet
Cape Cod National Seashore
Pilgrim Ln
Ireland Way
Foxwood Dr
Arrowood Dr
State Hwy
Ruggles Rd
Tonset Rd
Champlain Rd
Mill Pond Rd
Doane Rd
Nauset Heights Rd
Grandview Dr
Locust Rd
Canal Rd
Gibson Rd
Hopkins Ln
Great Oak Rd
Beach Rd
Hubler Ln
Cove Rd
Main St
Meetinghouse Rd
Loomis Ln
River Rd
Samoset Rd
Harveys Ln
Tides End Ln
Sea Mist Dr
Fox Ridge Dr
Gosnold Rd
Pond Rd
Gesner Rd
Monument Rd
Kezaks Ln
Twiss Rd
Pershing Ln
Areys Ln
Thayer Ln
Viking Rd
Namequoit Rd
Portanimicut Rd
Carlton Rd
Uncle Israel Rd
Forest Way
Davis Rd
Molley Bird Ln
Lowell Dr
Lake Dr
Townhee Ln
Ewing Dr
Nauset Rd
Payson Ln
Broad Creek
Cranberry Hwy
S Orleans Rd
Rt 28 S Orleans Rd

Figure 2

Site ecological information related to predation, bottom conditions and bathymetry is also presented, including absence of eelgrass beds, and sediment type, as these factors apply to the type of demonstration viable at the site. Each site description details the particular issues that favor a certain type of demonstration project. For example, the presence of significant populations of predators limits oyster growing locations. The sediment conditions at each site dictate whether bottom planting is feasible and whether oysters or quahogs are more appropriate. Oysters require a hard substrate on which to set during their late larval stage, or sandy bottom if they are planted as juvenile single, while quahogs can tolerate a sand/mud mix but can also grow in coarse substrates such as sand and gravel (Gosling 2003).

Based on a literature review, threshold site ecology parameters should have the following range of values:

Target Values for Site Ecology Parameters: Oysters

- Optimal salinity: 14 to 28 parts per thousand
- Optimal dissolved oxygen: >4 mg/L
- Food availability (Chlorophyll a): >2 µg/L
- Absence of major populations of predators such as oyster drill
- Absence of eelgrass
- Benthic conditions: hard bottom sediment
- pH range suitable for larvae (most sensitive stage of life cycle): 6.75 to 8.75
- Suitable annual temperature range: > -2 to ≤ 35 °C
- Optimal bathymetry (intertidal): 1 to 30 meters

Based on Whetstone, 2005; Gosling, 2003; Dame, 1996; Menzel. 1989; Stanley 1983.

Target Values for Site Ecology Parameters: Quahogs

- Optimal salinity: 20 to 25 parts per thousand
- Optimal dissolved oxygen: >4 mg/L
- Food availability (Chlorophyll a): >2 µg/L
- Absence of eelgrass
- Benthic conditions: bottom sediment a mix of sand and mud
- Suitable annual temperature range: > -6 to ≤ 35 °C
- Optimal bathymetry (intertidal): 1 to15 meters

Based on Gosling 2003; Dame 1996; Lorio 1994; Sellers 1984.

Surrounding Environment Data

Land use, access to the water, current uses, and neighborhood support for a demonstration are important considerations that are unique to each site. Specific access points are identified, and the character of the neighborhoods surrounding each potential demonstration site is discussed. Public uses such as boating, swimming and shell fishing are also critical. All sites have some form of public access available. The most convenient access is land-based, where a boat is not required to install, operate and maintain the demonstration project. Some of the proposed demonstration sites have fewer conflicting uses and more surface water on which to locate and operate. A preliminary assessment regarding the likelihood of neighbor support for a demonstration is also presented. These aspects of the surrounding environment are detailed in the site descriptions.

c. Potential Demonstration Site Descriptions

Nauset Harbor Watershed

(1) Town Cove

General - Town Cove was evaluated for both oyster aquaculture and CHR. An oyster aquaculture demonstration would include growing seed in an upweller, with transfer to floating bags once the seed reaches approximately 8 mm. At the end of the first growing season, oysters would be bottom planted and allowed to grow through a second season for recreational and commercial harvest once the oysters reached market size (3-inch). Some of the first year oysters could be overwintered in the floating bags. CHR would involve expanding the Town's current propagation program by purchasing seed at 25mm and bottom planting these quahogs in suitable locations in Town Cove for recreational and commercial harvest.

Site Ecology - The MEP Final Report for Nauset Harbor (2012) documents the necessary water quality parameters for Town Cove. Salinity ranges from approximately 32 ppt at the inlet to a minimum of 29 ppt near the head of the cove. Monitoring equipment that collects DO and chlorophyll *a* data in fifteen minute intervals was deployed in Town Cove as part of the MEP field investigations in 2003. This instrument was centrally located in the southern end of the estuary, approximately 1 mile from Hopkins Island and 4 miles from Nauset Inlet. DO levels at the bottom were frequently less than 2 mg/L and periodically approached 0 mg/L. DO levels < 3 mg/L were measured for 38 percent of the 29 day monitoring period. Food availability is indicated by chlorophyll *a* concentrations, which averaged 8.5 µg/L, exceeding the minimum site suitability threshold of 2 µg/L. Both by numerical thresholds as well as field confirmation that both quahogs and oysters are growing in Town Cove, it seems that there is adequate food supply to support shellfish growth in this estuary. Given the low DO concentrations in bottom waters, an oyster aquaculture demonstration would likely need to employ growing systems that suspend shellfish in the upper sections of the water column. Areas within this waterbody with higher DO levels would be better suited to quahog planting, to optimize growth rates. High salinity promotes predation, which is a significant issue in this waterbody.

The suitability of Town Cove for an oyster aquaculture or CHR demonstration is severely limited by the large population of oyster drills (*Urosalpinx cinerea)*. Other predators include moon snails (*Neverita duplicatus*) and starfish (*Asterios forbesis and A. vulgarism*). The Massachusetts Shellfish Officers Association and the Barnstable County Cooperative Extension urge against oyster propagation in areas that experience high predation by oyster drills. For this reason, the use of oyster aquaculture or oyster beds as part of CHR are not proposed for this site. Macroalgae accumulations also create significant fouling problems for gear-based systems. Because of oyster predation and fouling issues, Town Cove is mainly suitable for bottom propagation of quahogs. A population study to

determine baseline quahog numbers and sizes is recommended as a first step, prior to the initiation of a demonstration project. Assessing current quantities of quahogs will provide the basis for evaluating the increase in quahogs from additional propagation efforts undertaken as part of a demonstration. For the past four years, there have been red tide blooms in Town Cove during in the spring and summer. According to the Division of Marine Fisheries, red tide is a toxic dinoflagellate (*Alexandrium fundyense*), and blooms are most likely when water temperatures are between 52 – 54 degrees F. Red tide can produce neurotoxins that accumulate in shellfish, which if eaten in large quantities, can cause serious illness or even death. Sampling for red tide cysts in Town Cove occurred in 2015. A report on this data collection is pending.

Town Cove has a waterbody surface area of 390 acres, providing ample area for a shellfish demonstration for quahog propagation. The MEP model estimates a target nitrogen removal load for this sub-watershed of almost 6700 kg N/year. Shellfish suitability areas and eelgrass beds (*Zostera marina*) are shown in Figure 3, derived from MassGIS databases. At present, eelgrass has nearly disappeared from Town Cove: therefore siting conflicts associated with this resource are not expected. According to Division of Marine Fisheries (DMF) mapping, Town Cove has suitable habitat for quahogs and oysters. Historically, the Town has operated a successful quahog propagation program in Town Cove. The Orleans Natural Resources Department currently plants approximately 600,000, one inch (25mm) quahogs annually near Hopkins Island. The existing quahog population has not been quantified. In Orleans, a private aquaculture grant is currently growing oysters in Town Cove. There are also seventeen aquaculture lease sites in the Eastham section of Town Cove, although only fourteen are useable according to the Eastham Harbormater. An area around the shoreline, extending to the boat ramp at the Orleans Yacht Club and seaward to a depth of three feet (measured at low tide) is closed for shellfishing by the Shellfish Constable to promote a sustainable year round recreational fishery. These data confirm that portions of Town Cove could support the growth of both oysters and quahogs.

The tide range in Town Cove is approximately 5 to 6 feet. Bathymetry data contained in the MEP Report and field verification with the Orleans Assistant Harbormaster document that at mean high tide, Town Cove north of Rocky Point has a maximum depth of 6.5 feet. At low tide, water is less than 2 feet deep. Over half of Town Cove is less than 8 feet deep at mean low tide. There is a basin (near 13 feet at low tide) located midway between Rocky Point and the Orleans Yacht Club, on the east side of Town Cove. Water depths are adequate to support both oyster and quahog growth. Sediment grain size varies throughout Town Cove, with some areas of coarse sand and other areas of fine-grained, organic rich materials.

Surrounding Environment - The land surrounding Town Cove is fully developed, with residential land use on the east side, and commercial uses along route 6A on the western shore. This estuary is a popular recreation destination, enjoyed by boaters of all types, swimmers, and shell fishers. There are several public boat landings, as well as private docks and a marina. Access to any demonstration project would be possible, but would require a boat. Overall, there are no parameters that preclude a demonstration at Town Cove.

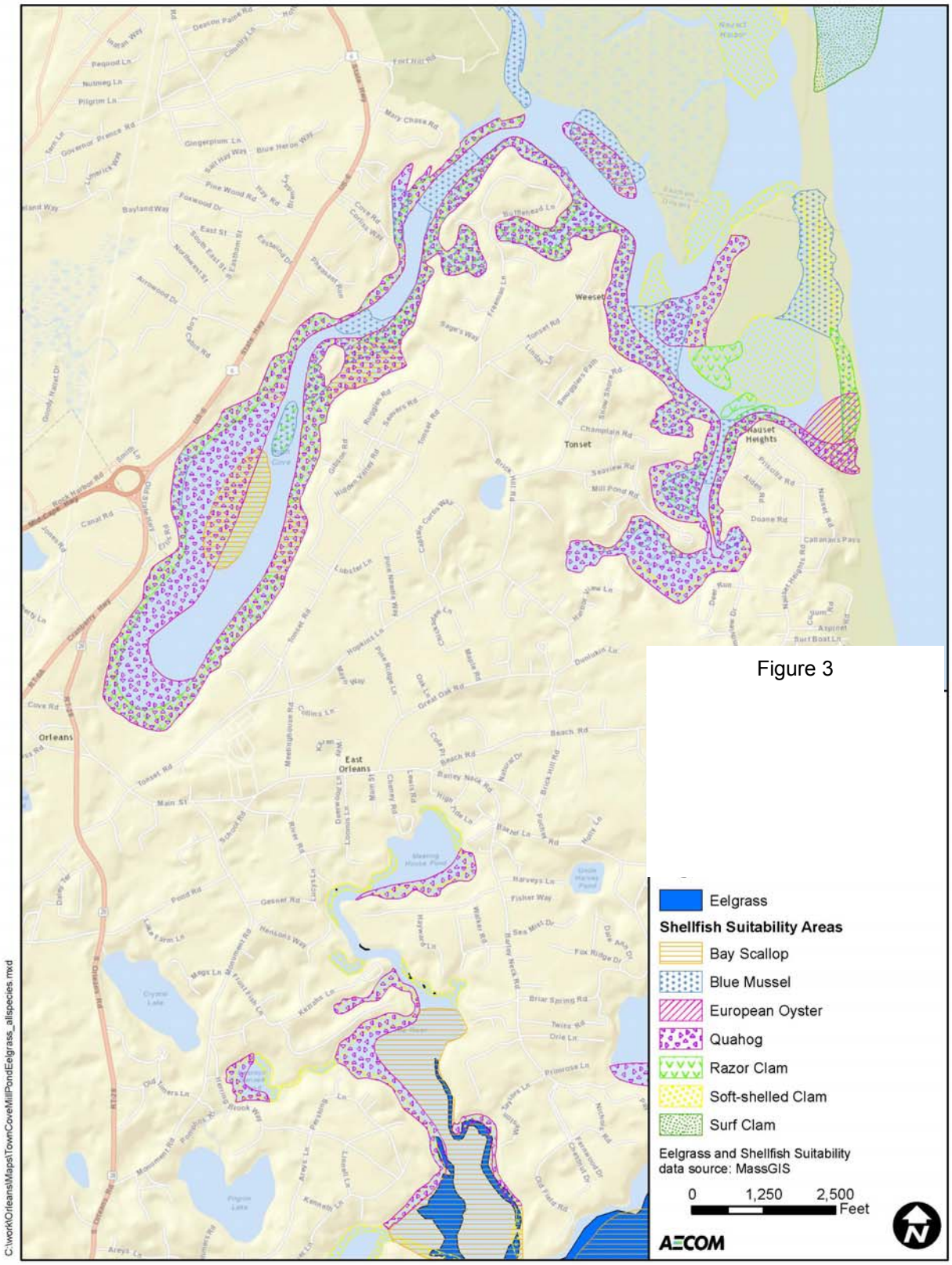

Eelgrass
Shellfish Suitability Areas
Bay Scallop
Blue Mussel
European Oyster
Quahog
Razor Clam
Soft-shelled Clam
Surf Clam
Eelgrass and Shellfish Suitability data source: MassGIS
0
1,250
2,500
Feet
AECOM
C:\work\Orleans\Maps\TownCoveMillPondEelgrass_allspecies.mxd
Orleans
East Orleans
Tonset
Weeset
Nauset Heights

Figure 3

(2) Mill Pond

General - Mill Pond was evaluated for both oyster aquaculture and CHR. An oyster aquaculture demonstration would include growing seed in an upweller, with transfer to floating bags once the seed reaches approximately 8mm. At the end of the first growing season, oysters would be bottom planted and allowed to grow through a second season for recreational and commercial harvest once the oysters reached market size (3"). Some of the first year oysters could be overwintered in the floating bags. When overwintering in bags, locations must be deep enough to avoid potential ice damage. CHR involves expanding the Town's current propagation program by purchasing seed at 25mm and bottom planting these quahogs in suitable locations in Mill Pond for recreational and commercial harvest.

Site Ecology - The MEP Final Report for Nauset Harbor (2012) documents water quality parameters for Mill Pond. Salinity is approximately 30 ppt. Monitoring equipment that collected DO and chlorophyll *a* data in fifteen minute intervals was deployed in Mill Pond as part of the MEP field investigations in 2003. This instrument was located at a depth of 12 feet, off the Mill Pond boat launch, to avoid this estuary's deep basin, yielding a more representative water sample. This station is approximately 3 miles from Nauset Inlet, in the main basin of Mill Pond. DO levels measured using this continuous sensor were typically between 6 mg/L and 8 mg/L. Since 2003, DO levels periodically drop to zero mg/L in water quality monitoring data that is collected at a single point in time during the July and August sampling period. Food availability, indicated by chlorophyll *a* concentrations, averaged 10.8 µg/L, exceeding the minimum site suitability threshold of 2 µg/L. By numerical thresholds as well as field confirmation that both quahogs and oysters are growing in Mill Pond, it seems that there is adequate food supply and DO to support shellfish growth in this estuary. High salinity promotes predation, which is a significant issue in this waterbody.

There are two volunteer-led oyster aquaculture projects in Mill Pond. A group of residents have worked with the Shellfish Constable and Barnstable County Cooperative Extension to plant oyster spat-on-shell, and the Orleans Pond Coalition grows approximately 50,000 oyster singles from seed in an upweller located at the Arey's Pond Boat Yard and relays them to Mill Pond where these oysters are grown-out in cages. The suitability of Mill Pond for an oyster aquaculture or CHR demonstration is severely limited by the large population of oyster drills (*Urosalpinx cinerea)*. The Massachusetts Shellfish Officers Association and Barnstable County Cooperative Extensionand urge against oyster propagation in areas that experience high predation by oyster drills. For this reason, the use of oyster aquaculture or oyster beds as part of CHR are not proposed for this site. Mill Pond is mainly suitable for bottom propagation of quahogs, outside the deep basin. A population study to determine the baseline quahog numbers and sizes is recommended.

Mill Pond has a waterbody surface area of 81 acres, providing ample area for a quahog shellfish demonstration. The MEP model does not estimate a specific target nitrogen removal load for this sub-watershed but the load reduction target for the entire Nauset System, not including Town Cove, is approximately 1900 kg N/year. Shellfish suitability areas and eelgrass beds (*Zostera marina*) are shown in Figure 4, derived from MassGIS databases. Mill Pond does not have a history of eelgrass beds; therefore, siting conflicts with this resource are not anticipated. Although local observations report eelgrass in the in Mill Pond late 1970's. According to Division of Marine Fisheries (DMF) mapping, Mill Pond has suitable habitat for quahogs and oysters. Historically, the Town has propagated quahogs in Mill Pond, but current populations have not been quantified. These data confirm that both oysters and quahogs could be grown as part of a demonstration.

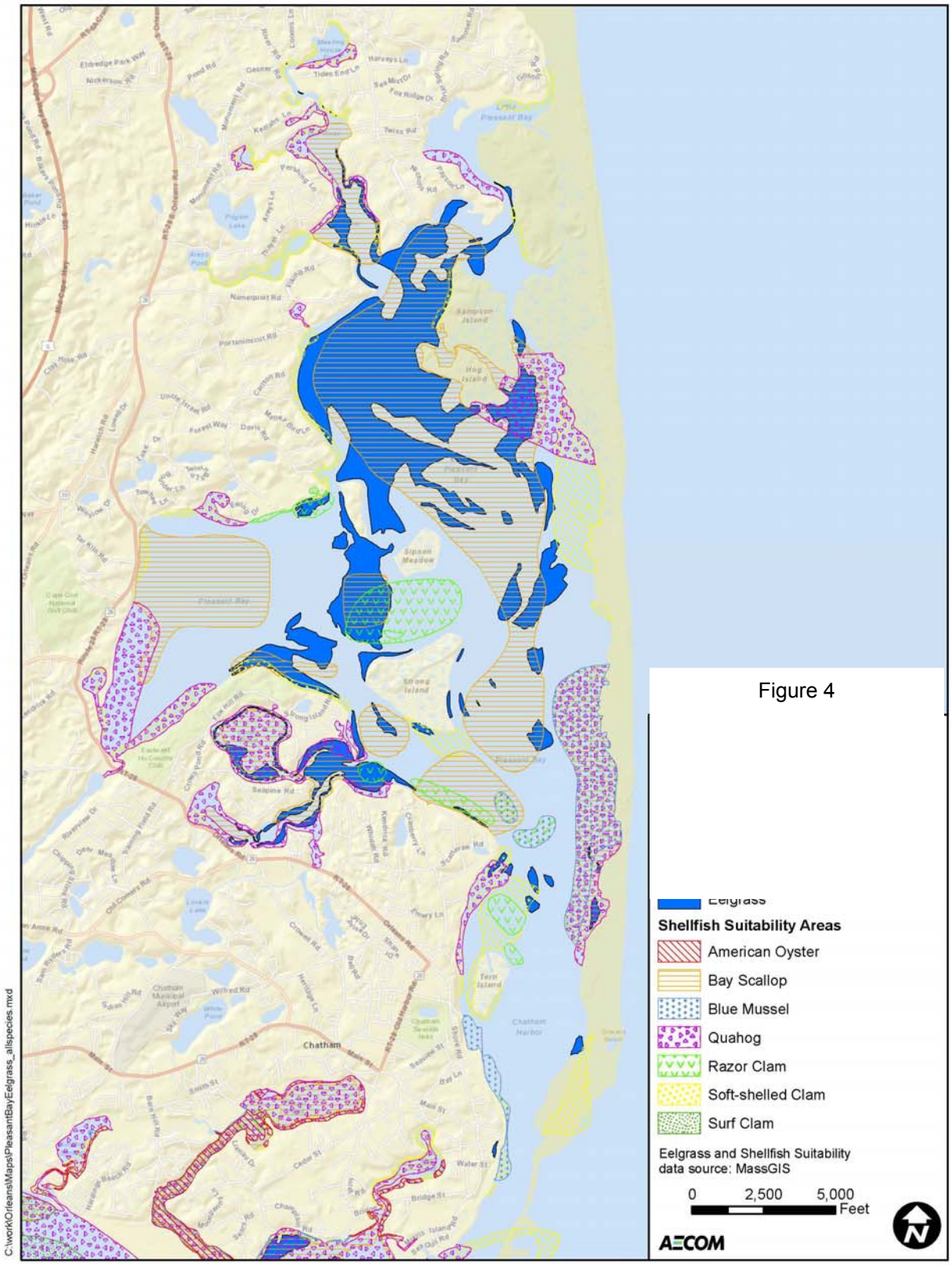

Eelgrass
Shellfish Suitability Areas
American Oyster
Bay Scallop
Blue Mussel
Quahog
Razor Clam
Soft-shelled Clam
Surf Clam
Eelgrass and Shellfish Suitability
data source: MassGIS
0
2,500
5,000
Feet
AECOM
C:\work\Orleans\Maps\PleasantBay\Eelgrass_allspecies.mxd
Chatham

Figure 4

The tidal range in Mill Pond is approximately 5 to 6 feet. Bathymetry data document that at mean low tide, water depth is an average of 15 to 18 feet. Mill Pond has a deep basin greater than 26 feet. Water depths are adequate to support both oyster and quahog demonstrations. Sediment grain size varies throughout Mill Pond, with some areas of coarse sand and other areas of fine-grained silt, particularly in the deep basin. Quahog propagation should be possible given this sediment regime.

Surrounding Environment - The land surrounding Mill Pond is a developed, residential area. Mill Pond has a family shell fishing area as well as a mooring field. There is also a small public boat launch area off Mill Pond Road. Access to any demonstration project would be possible, but would require a boat. Overall, there are no parameters that preclude a demonstration at this site.

Pleasant Bay Watershed

(1) Little Pleasant Bay

General - Little Pleasant Bay was evaluated for aquaculture and CHR. An oyster aquaculture demonstration would potentially involve working with some of the current operators of the Town's shellfish grants to evaluate and potentially enhance production. CHR would involve purchasing remote set (shells on which oyster seed has been set in controlled environment), growing in floating bags and trays for 8 to 12 weeks, and bottom planting to establish an oyster bed.

Site Ecology - Data for Little Pleasant Bay was found in reports by the MEP (2006) and the Pleasant Bay Alliance Water Quality Monitoring Program (Cadmus Group 2015). MEP did not deploy a monitoring instrument in Little Pleasant Bay as part of their field investigations. However, for the past fifteen years, a program of the Pleasant Bay Alliance's monitoring program collected water quality data during July and August. A monitoring station in Little Pleasant Bay, located between Old Field Point and Sampson Island, is approximately 1800 feet from the current shellfish grants. Based on this data, salinity is approximately 30 ppt and dissolved oxygen levels are over 5 mg/L. Food availability, as indicated by total pigment concentrations (chlorophyll *a* + phaeophytin *a*), declined significantly from 2002 to 2014, dropping from 4.5 µg/L to 2 µg/L. Therefore, food concentrations are approaching the minimum site suitability threshold of 2 µg/L. It will be important to collect data within the existing shellfish grants to determine whether this low concentration of total pigment is also occurring within the grant areas. This information will help develop rational expectations for shellfish harvest yields.

Little Pleasant Bay has a waterbody surface area of 270 acres, with approximately 120 acres identified as acceptable for demonstration sites(the area containing the current shellfish grants). The MEP model estimates a target nitrogen removal load for this sub-watershed of almost 824 kg N/year. The120 acres provide ample area for a shellfish demonstration and expansion. Shellfish suitability areas and eelgrass beds (*Zostera marina*) are shown in Figure 4, derived from MassGIS databases. At present, there are some eelgrass beds in Little Pleasant Bay, but not within the demonstration site area. According to DMF mapping, Little Pleasant Bay does not have suitable habitat for quahogs and oysters. However, both quahog and oyster aquaculture has been productive in this location. A demonstration project in Little Pleasant Bay would build on this success.

The tidal range in Little Pleasant Bay is approximately 5 to 6 feet. Bathymetry data from National Oceanic and Atmospheric Administration (NOAA) show that the depth of Little Pleasant Bay at mean low tide is 2 to 3 feet in many areas. Sediment grain size at the demonstration site in Little Pleasant Bay is dominated by coarse sand, with some areas of fine sand. These features make it possible to operate and maintain a demonstration by standing in the water during low tide, and potentially identifying areas for bottom planting oysters.

Surrounding Environment - The land surrounding the Little Pleasant Bay site is a developed residential area. This estuary is a popular recreation destination, enjoyed by boaters of all types, swimmers, and shellfishers. There are several public boat landings, private docks and a marina at Meetinghouse Pond. Access to any demonstration project would be possible, but would require a boat. Overall, there are no parameters that preclude a demonstration at this site.

This site provides a unique opportunity to engage the local shellfish grant holders in a demonstration project. These growers are using floating bags, racks and cages for oyster and some quahog aquaculture. There are currently 12 grants in operation, with several new areas proposed by the Shellfish Constable, producing a total combined harvest of approximately 1 million oysters annually. Figure 2 shows the location of these grants. The Orleans Assistant Harbormaster and Shellfish Constable/Harbormaster both suggested working with these growers to develop a demonstration project because grant holders already have the expertise, infrastructure and interest in aquaculture.

(2) Arey's Pond

General - Arey's Pond was evaluated for oyster aquaculture. An oyster aquaculture demonstration would include growing seed in an upweller, with transfer to floating bags once the seed reaches approximately 8 mm. At the end of the first growing season, oysters would be relayed to other locations for second-year growth because there is no suitable bottom in Arey's Pond. These oysters would then be available for recreational and commercial harvest once the oysters reach market size (3-inch). Some of the first year oysters could be overwintered in the gear and grown out in Arey's Pond, but the gear densities for second year growth are much lower than for first year. Because of space constraints, some of the first year oysters would need to be relayed to other locations.

Site Ecology - The MEP (2006) and the Pleasant Bay Alliance Water Quality Monitoring Program (Cadmus Group 2015) document water quality parameters that are fundamental to shellfish propagation. Salinity in Arey's Pond is approximately 26 ppt. Monitoring equipment that collects DO and chlorophyll *a* data in fifteen minute intervals was deployed in Arey's Pond as part of the MEP field investigations in 2003. The continuous monitoring station was centrally located in the pond. DO concentrations less than 2 mg/L were measured for 63 percent of the 36 day monitoring period. Recent data compiled by the Cadmus Group (2015) confirms that this anoxic condition persists. Food availability, measured by chlorophyll *a* concentrations, averaged 12.5 µg/L in 2003, exceeding minimum site suitability threshold of 2 µg/L. As part of the Pleasant Bay Alliance monitoring program, total pigment concentration (chlorophyll a + phaeophytin) data has been collected since 2008. The total pigment data, therefore food availability, is approximately 7 µg/L. Food supply is adequate to support shellfish growth in this estuary. Given the low DO of bottom waters, oyster aquaculture should employ growing systems that suspend shellfish in the upper sections of the water column.

Arey's Pond has a waterbody surface area of 13 acres, with a limited area for a shellfish demonstration because a mooring field occupies most of the pond. The MEP model estimates a target nitrogen removal load for this sub-watershed of almost 142 kg N/year. Shellfish suitability areas and eelgrass beds (*Zostera marina*) are shown in Figure 4, derived from MassGIS databases. At present there are no eelgrass beds in Arey's Pond, therefore siting conflicts associated with this resource are not anticipated. According to DMF mapping, Arey's Pond has suitable environmental conditions for quahogs and oysters.

The tidal range in Arey's Pond is approximately 5 feet. Bathymetry data from NOAA indicate that at mean low tide the water depth at the center of the pond is 14 feet, and areas along the perimeter and at the entrance from Namequoit River are 6 feet. Sediment grain size in Arey's Pond is dominated by very fine silt, rich in organic matter, precluding bottom planting of shellfish. Water depth dictates that a demonstration project would be worked by boat.

Surrounding Environment - The land surrounding Arey's Pond is a densely developed residential area. This estuary contains a dense mooring field covering most of the water area. Arey's Pond has a public access footpath, private docks and a commercial marina. The Orleans Pond Coalition uses an upweller located at this marina to grow approximately 50,000 oyster singles that are ultimately relayed to Mill Pond. Access to a demonstration project would be possible, but would require a boat for operation and maintenance and a confirmation of support from the neighbors that has been initially expressed. Overall, there are no parameters that preclude a demonstration at this site.

(3) Pochet

General - Pochet was evaluated for CHR, which would involve purchasing remote set (shells on which oyster seed has been set in controlled environment), growing in floating bags and trays for 8 to 12 weeks, and bottom planting to establish a bed environment.

Site Ecology - The MEP (2006) and the Pleasant Bay Alliance Water Quality Monitoring Program (Cadmus Group 2015) document water quality parameters for Pochet. Salinity in Pochet is approximately 30 ppt. Monitoring equipment that collects DO and chlorophyll *a* data in fifteen minute intervals was deployed in Pochet as part of the MEP field investigations in 2003. However, the station is approximately 2000 feet from the proposed demonstration sites. DO levels less than 5 mg/L but greater than 4 mg/L were measured for 50 percent of the 52 day monitoring period. Recent data compiled by the Cadmus Group (2015) shows that since 2008, DO levels have been approximately 3 mg/L at a monitoring station that is closer to the head of Pochet, approximately 3000 feet (linear distance) from the demonstration site. Figure 5 shows the Pleasant Bay Alliance monitoring station locations. Food availability, measured by chlorophyll *a* concentrations, averaged 5 µg/L during the 2003 MEP field investigation (exceeding minimum site suitability threshold of 2 µg/L). In 2004, the chlorophyll *a* concentration was 3 µg/L at a monitoring station in the same location as the MEP continuous monitoring equipment. There has not been additional data collected near this demonstration site for chlorophyll *a* or total pigment concentrations since 2004. Based on these data, Pochet has adequate food supply and DO levels to support shellfish bottom growth in this estuary.

Pochet has a waterbody surface area of 140 acres, ample area for a shellfish demonstration and expansion. The MEP model estimates a target nitrogen removal load for this sub-watershed of almost 413 kg N/year.

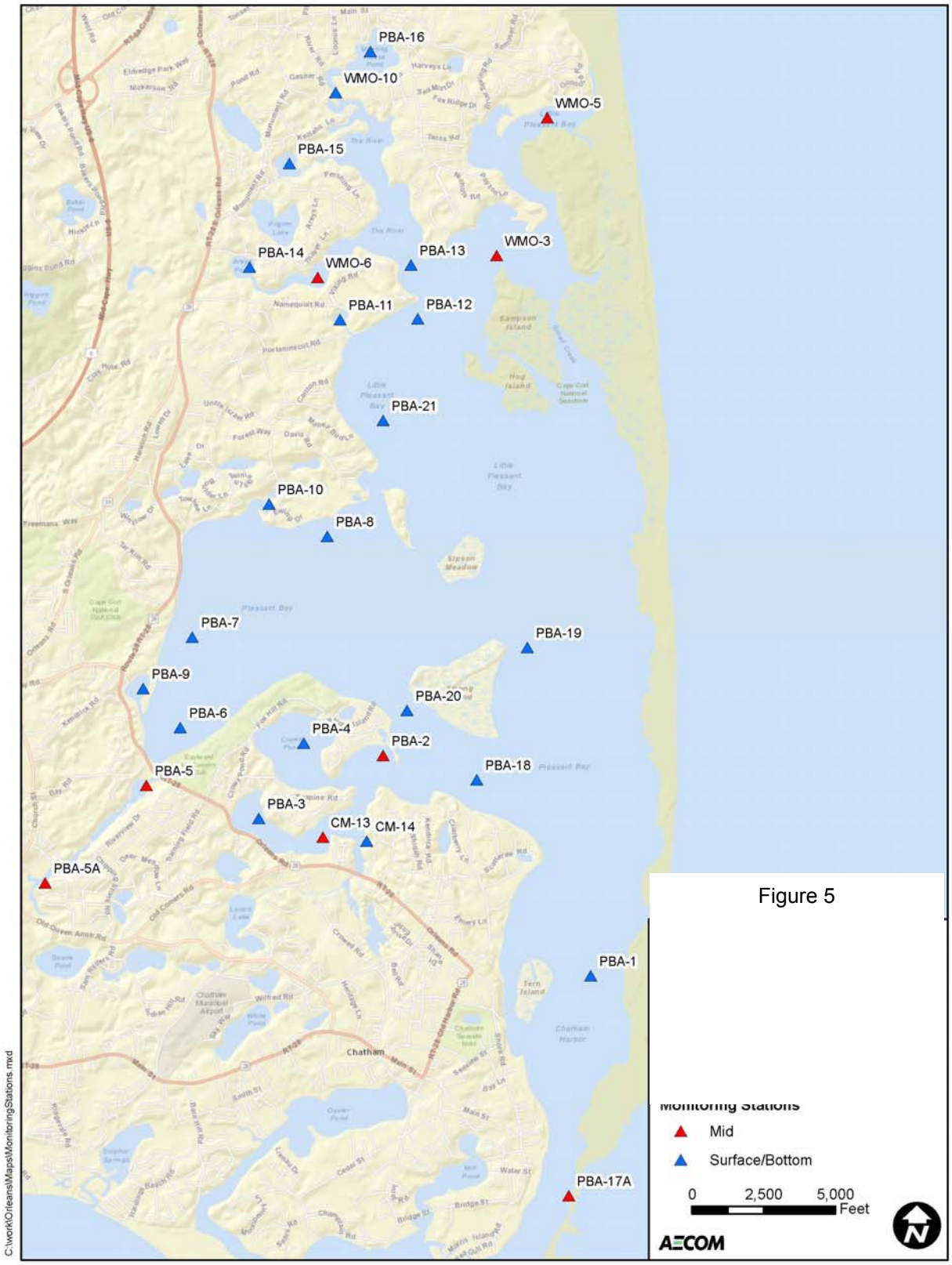

PBA-16
WMO-10
WMO-5
PBA-15
PBA-14
WMO-6
PBA-13
WMO-3
PBA-11
PBA-12
PBA-21
PBA-10
PBA-8
PBA-7
PBA-19
PBA-9
PBA-20
PBA-6
PBA-4
PBA-2
PBA-5
PBA-18
PBA-3
CM-13
CM-14
PBA-5A
PBA-1
Chatham
PBA-17A
Monitoring Stations
Mid
Surface/Bottom
0
2,500
5,000
Feet
AECOM
C:\work\Orleans\Maps\MonitoringStations.mxd

Figure 5

Shellfish suitability areas and eelgrass beds (*Zostera marina*) are shown in Figure 4, derived from MassGIS databases. At present there are two small patches of eelgrass in Pochet, but during the team's field investigation, it was verified that eelgrass is not present at the demonstration site. According to DMF mapping, Pochet has suitable habitat for quahogs and other species not currently being considered for a demonstration. Given the success of oyster aquaculture in the nearby aquaculture grants, it is likely that oysters will grow at this site as well as quahogs.

The tidal range in Pochet is approximately 5 to 6 feet, with the range reported in the MEP Report of up to 9 feet along some areas of Pochet Island. Bathymetry data from NOAA show that this estuary is generally shallow. At mean low tide, the water depth at the Pochet inlet is 2 feet, with depths varying widely near the vicinity of the demonstration site. Only a shallow draft or pontoon-style boat would be suitable for working a project at this location. . Field investigation confirmed that the proposed demonstration area is shallow, approximately 3 feet. Sediment grain size at the demonstration site, and in this general area is coarse sand. Shifting substrate may cause siltation issues for any bottom-planted oysters.

Surrounding Environment - he land surrounding Pochet is residential, with a private island bordering the demonstration location. This site is also contained within the boundary of the Cape Cod National Seashore (CCNS). Access to a demonstration project would be possible, but would require a boat for operation and maintenance. Support of the neighbors and permission from the National Park Service is required. These two factors must be addressed before a demonstration project proceeds at this site.

(4) Lower River

General - Lower River was evaluated for aquaculture and CHR along the shore of Kent's Point. CHR involves purchasing remote set (shells on which oyster seed has been set in controlled environment), growing in floating bags and trays for 8 to 12 weeks, and bottom planting to establish a bed environment.

Site Ecology - The MEP (2006) and the Pleasant Bay Alliance Water Quality Monitoring Program (Cadmus Group 2015) document water quality parameters in Lower River. Salinity in Lower River is approximately 30 ppt. Monitoring equipment that collects DO and chlorophyll *a* data in fifteen minute intervals was deployed near Kent's Point as part of the MEP field investigations in 2003. The equipment recorded DO levels between 4 mg/L and 5 mg/L for 78 percent of the 36 day monitoring period. Recent data compiled by the Cadmus Group (2015) in the Upper River indicates that since 2008, DO levels have risen from 4 mg/L to over 5 mg/L. Food availability, measured as chlorophyll *a* concentrations averaged 8.5 µg/L at the Namequoit River monitoring location during the 2003 MEP field investigations, exceeding the minimum site suitability threshold of 2 µg/L. This monitoring location is very near the demonstration site. As part of the Pleasant Bay Alliance monitoring program, total pigment concentrations (chlorophyll *a* + phaeophytin *a*) have been collected at two stations. Total pigment concentration has been declining since 2000 at both stations, with current concentrations at 3 µg/L. Based on these data, there seems to be adequate food supply and DO levels to support shellfish bottom growth in this estuary.

Lower River near Kent's Point has a waterbody surface area of 20 acres, adequate for a shellfish demonstration. The MEP model estimates a target nitrogen removal load for this sub-watershed of almost 524 kg N/year. Shellfish suitability areas and eelgrass beds (*Zostera marina*) are shown in Figure 3, derived from MassGIS databases. At present there is only a small patch of eelgrass near the eastern edge of the shore, and during the team's field investigation, it was verified that eelgrass is not present at the potential demonstration site. According to DMF mapping, Lower River in the vicinity of Kent's Point has suitable habitat for quahogs, although it is likely that oysters will grow as well.

The tidal range in the Lower River is approximately 5 to 6 feet. Bathymetry data from NOAA indicate that this estuary is generally shallow. At mean low tide, the water depth at the demonstration site is 2 to 4 feet, enabling a demonstration to be worked without a boat. Sediment grain size is dominated by very fine silt throughout this area, which precludes bottom planting of oyster remote set as part of a bed installation as gear, such as trays, would be required.

Surrounding Environment - The land surrounding Lower River is the Kent's Point conservation area. This area has good visibility, visitation and access, which facilitate education and outreach activities. This location can be accessed from the shore, and does not require a boat for installation, operation or maintenance of a demonstration project. This estuary is a popular recreation destination, enjoyed by boaters of all types, swimmers, and walkers. Water skiers and dinghy sailors frequent this area. Floating gear may create user conflicts relating to aesthetics as well as navigation. Overall, there are no parameters that preclude a demonstration at this site, but use conflicts may be an issue.

(5) Quanset Pond

General - Quanset Pond was evaluated for aquaculture and CHR. CHR involves purchasing remote set (shells on which oyster seed has been set in controlled environment), growing in floating bags and trays for 8 to 12 weeks, and bottom planting to establish a bed environment.

Site Ecology - The MEP Final Report for Pleasant Bay (2006) and the Pleasant Bay Alliance Water Quality Monitoring Program Report (Cadmus Group 2015) document water quality parameters for Quanset Pond. Salinity is approximately 30 ppt. A monitoring instrument that collected DO and chlorophyll *a* data in fifteen minute intervals was deployed in Quanset Pond as part of the MEP field investigations in 2003. This station recorded DO levels less than 5 mg/L but greater than 4 mg/L for 48 percent of the 36 day monitoring period. Recent data compiled by the Cadmus Group (2015) indicates that since 2008, DO levels have risen from 4 mg/L to 5 mg/L. Food availability, measured by chlorophyll *a* concentrations averaged 8.9 µg/L at the Quanset Pond monitoring location during the 2003 MEP field investigations, exceeding the minimum site suitability threshold of 2 µg/L. The MEP monitoring location is very near the demonstration site. As part of the Pleasant Bay Alliance monitoring program since 2008, data for total pigment concentrations (chlorophyll a + phaeophytin) has been collected and is approximately 5µg/L. Based on these data, there seems to be adequate food supply, and DO levels to support shellfish bottom growth in this estuary.

Quanset Pond has a waterbody surface area of 13 acres, adequate for a shellfish demonstration and providing some expansion potential. The MEP model estimates a target nitrogen removal load for this sub-watershed of approximately 256 kg N/year. Shellfish suitability areas and eelgrass beds (*Zostera marina*) are shown in Figure 4, derived from MassGIS databases. At present there is no eelgrass near the demonstration site. According to DMF mapping, Quanset Pond has suitable habitat for quahogs, but it is likely that oysters will grow here as well.

The tidal range in Quanset is approximately 5 to 6 feet. Bathymetry data from NOAA indicate that this area is generally shallow. At mean low tide, the depth at the center of Quanset is 7 feet, with a depth of 0.5 feet at the demonstration site. Sediment grain size is dominated by coarse sand at the demonstration location, which is suitable for bottom planting of remote set. There is also a hydroconnection from Meadow Bog Pond and Sarah's Pond to Little Quanset Pond. Meadow Bog Pond is extremely shallow, and Sarah's Pond experiences an annual cyanobacteria bloom during the summer.

Surrounding Environment - The land surrounding Quanset Pond is moderate-density residential. This area has good visibility, visitation and access, which facilitate education and outreach activities. This location can be accessed from the shore, and does not require a boat for installation, operation or maintenance of a demonstration project. This estuary is a popular recreation destination, with a small mooring field in the deeper part of the basin. The demonstration site would not interfere with navigation or public enjoyment. Aesthetic impacts are mitigated by the fact that the use of surface gear is temporary and that it would be located outside the main beach area. Once the bed is established, any use of floating bags will be discontinued. Overall, there are no parameters that preclude a demonstration at this site.

4. Site Evaluation and Screening Criteria

To facilitate a systematic and objective evaluation of each of the potential demonstration sites, a decision support tool, called 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:

a. 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

b. Permitting

- Abutter Compatibility
- Wild Harvest Conflicts (DMF)
- Grow-Out to Harvest Size Allowed (DMF)
- Permittability

c. Project Evaluation

- Expected Survival
- Overall Likelihood of Monitoring Plan to Yield Quantified Results

The specific criteria within each evaluation category are defined as follows:

a. Site Suitability

- Available Growing Area/Adequacy of Acreage: an assessment of whether the amount of waterbody surface area is sufficient to implement the demonstration, and whether expansion potential exists.
- Water Quality Indicators: the environmental conditions needed to support shellfish growth. Key parameters include chlorophyll *a*, dissolved oxygen (DO), and salinity.
- Disease/Predation: presence of a population of predators that are likely to have a significant negative impact on survival of shellfish cultivated as part of a demonstration project.
- Ease of Access: locations are available from which demonstration sites can be installed, operated and maintained.
- Aesthetic Impacts: the visual impression that the project will have on vistas around the site.
- Representativeness of the Site (Transferability): a demonstration at this location would inform potential for shellfish to grow in other areas
- Use Conflicts: the likelihood that the proposed shellfish demonstration can occur without impeding the other activities currently taking place at proposed demonstration sites. This criteria evaluates whether there will be objections from the community of people who use the waters near the proposed demonstration sites both recreationally (boating, swimming, passive enjoyment) and for wild harvest of shellfish.
- Ability to Co-Locate with other Non-Traditional Technologies: As part of a post-demonstration, full-scale implementation strategy it is feasible to add floating constructed wetlands at this site in order to take advantage of any enhanced nitrogen uptake that may result.

b. Permitting

- Abutter Compatibility: the likelihood that the proposed shellfish demonstration can occur without significant objections from adjacent landowners and residents.

- Wild Harvest Conflicts: there are no populations (standing stock) of organisms that are currently harvested, which could trigger a denial of permission from DMF for a demonstration.

- Grow-Out to 3-inch Allowed: the sites are not closed to shellfishing, which would preclude grow out to harvest size.

- Permittability: there are no activities associated with the demonstration project that are prohibited activities under the Wetlands Protection Act, the Pleasant Bay Area of Critical Environmental Concern, Army Corps of Engineers regulations or Division of Marine Fisheries guidelines.

c. Project Evaluation

- Expected Survival: based on field evaluations, there is overall likelihood that shellfish grown at the demonstration site will live to harvest size

- Overall Likelihood of Monitoring Plan to Yield Quantified Results: based on review of map locations, watershed loading and water quality data, it is reasonable to expect that monitoring at a particular demonstration site will show statistically significant changes in water quality parameters, specifically chlorophyll a, total nitrogen and water clarity.

- Based on the MEP model, both the Nauset Harbor and Pleasant Bay System watersheds have recommended total nitrogen (TN) removal rates that are significantly higher than the expected TN removal of a shellfish demonstration project. The target nitrogen load reduction for the entire Pleasant Bay System is almost 17 million kg N/year, with each sub-watershed in the Pleasant Bay system having a lower target nitrogen removal rate than the system as a whole. Since the system circulates, it is not likely that a small uptake of nitrogen in just one sub-embayment will register a reduced TN concentration at the sentinel station in that sub-embayment, even if it is a significant percent of the nitrogen load reduction for that sub-watershed. The target nitrogen load reduction for the Nauset Harbor system is approximately 8600 kg N/year, while the Town Cove sub-embayment target load reduction is approximately 6700 kg N/year. Therefore, to quantify the nitrogen-removal of a demonstration project, monitoring plans will need to be designed to capture localized water quality improvements near the demonstration sites. This is accomplished by positioning monitoring stations upstream, instream and downstream of the demonstration site, with high spatial resolution. Sites with clearly defined upstream and downstream locations ranked highest for the criterion that monitoring plans will yield quantitative results.

5. 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.

For the Site Suitability criteria, if a site was fully suitable based on the criterion being ranked it was assigned a numerical value of 1, if the site was mostly suitable based on the criterion being ranked it was assigned a ranking of 0, and if the site was unsuitable it was assigned a ranking of -1.

For the Permitting criteria, if a site was likely to be permitted based on the criterion being ranked it was assigned a numerical value of 1; if the site was likely to be permitted, but there were potential issues based on the criterion being ranked, it was assigned a ranking of 0; and if the site was unable to be permitted within a particular criteria, it was assigned a ranking of -1.

For the Project Evaluation criteria, if a site was likely to produce a successful demonstration based on the criterion being ranked it was assigned a numerical value of 1, if the site was probably able to produce a successful demonstration based on the criterion being ranked it was assigned a ranking of 0, and if a demonstration was unlikely to succeed at a site, based on a particular criterion, it was assigned a ranking of -1.

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 GIS maps from the DMF, preliminary grain size maps from Center for Coastal Studies 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 ensure 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. Results are discussed in Section 6.

6. Findings/Recommendations: Summarize 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 are 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 Engineering Work Plan for this option will be detailed in the subsequent TM, but 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. A preliminary monitoring plan has already been developed for this site (Science Wares, 2015). 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.

Arey's Pond is space-constrained, and the sediment is unsuitable to bottom planting for second year grow-out. Thus, this site does not have good replicability to other areas. Pursuing a shellfish demonstration in Town Cove or Mill Pond is not recommended 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. Finally, given the potential use conflicts and difficulty of monitoring yielding quantifiable results, the Lower River is the least attractive site for a demonstration.

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Appendix A

General Comments or Notes from Chatham Shellfish Propagation

Comments from Ed Daly

Comments from Sandy MacFarlane

Comments from Dave Slack

General Comments or Notes from Chatham Shellfish Propagation and AECOM Shellfish Team Responses (in red) provided below.

Thank you for providing your comments and suggestions to the Technical Memorandum, we appreciate your input to this process.

GENERAL RESPONSE: Please also read our response to the comments from Cape Cod Cooperative Extension. Here, we explain in greater detail why the specifics of a demonstration project design are going to be the subject of the next Technical Memorandum, entitled "Preliminary Engineering and Design Work Plan". We will also note in the Purpose section of the Final Site Characterization and Evaluation Technical Memorandum that preliminary engineering and design are addressed in a subsequent Technical Memorandum.

1. After reading the general AECOM memo for the Orleans Water Project here are a few comments or notes that came to light from the standpoint of Shellfish Propagation in a neighboring town. At no point in the memo was quantity or numbers discussed which makes use of gear and feasibility hard to judge as a realistic project. Growing 30,000 shellfish is very different and often requires different methods than growing 3,000,000.

   RESPONSE: The purpose of this Tech Memo is to characterize the sites for demonstration projects. This is not the design and monitoring plan for a demonstration, which is the subject of the next Tech Memo.

2. Setting that aside one of the major discussions missing from the memo was any discussion of predators or disease with the exception of a mention of oyster drills in Town Cove. Other predators and disease exist in these systems and water bodies and their absence or presence often dictates the methods used for growth. Predators such as, green crabs, blue crabs, starfish, moon snails to name a few are all present in these bodies of water and protection methods are needed in order to produce viable shellfish. Disease has also been known to be present and Best Management Practices are needed in order to minimize the chance of disease or spread.

   RESPONSE: We agree with your comment and the site engineering and the monitoring plans will include in detail the need for baseline studies and monitoring of disease and predation

3. The use of floating gear for oyster aquaculture has been a game changer for many growers and resource mangers. However, there are often draw backs with floating gear. The use of floating gear increases the size of the area (footprint) that it takes to grow your animals and also increases conflicts with boaters and moorings. Utilizing floating gear in a small pond with many moorings like Arey's Pond is not always a good options as the hazards to navigation caused to boaters can be detrimental to the project. Utilizing floating gear can be labor intensive for large scale operations. In Massachusetts and most northern areas floating gear can not remain floating in the winter time due to the hazards from ice and winter storms. The gear must be sheltered enough that I doesn't get affected by large wind events in the summer. A large pond area with no boating activity is ideal. Although there are not any specific discussions about methods to be utilized, the memo mentions putting Remote Set in floating bags multiple times. Floating remote set, although possible would not be a feasible option for most operations.

   RESPONSE: We agree with your comment that gear is both a game-changer and a challenge to site. The site engineering and the monitoring plans will include an assessment of the feasibility of gear-based systems in the specific locations where gear is recommended.

4. One of the targets listed for growing oysters was the necessity for having a hard bottom. If growing these animals on the bottom sediment this is needed, however this report mainly discusses growing seed oysters in floating gear and then transferring to a secondary broadcast area. The initial area can be located regardless of bottom conditions, and then the broadcast area can be anywhere. From an enforcement standpoint, broadcasting sub-legal oysters makes for additional labor enforcing these newly planted oyster beds. From recreational harvesters taking seed to grant holders transferring seed to their grants for final grow out, often restoration oyster beds are too good to resist for poaching.

   RESPONSE: We agree with your comment, and are focusing on areas that are visible and easily patrolled. And, additional staffing hours will be required to maintain adequate patrol.

5. This memo is a general site characterization, but more detail on the methods and quantity of shellfish are needed to truly evaluate the project from a propagation standpoint. Some of the water quality data is over 13 years old and some of the sites were almost ½ mile from the proposed sites. Water data and conditions change year to year and more fine scale information should be collected and reviewed.

   RESPONSE: Because the purpose of this Tech Memo is to characterize the sites for demonstration projects with the specifics of the design as well as monitoring plan as subject of the next Tech Memo, many details are not included. Baseline monitoring at the demonstration sites are an important first step in implementation.

We very much appreciate your comments and questions!

Comments from Ed Daly (in black) and AECOM Shellfish Team Responses (in red) provided below.

Comments on:

- Letter Report 12-1-15 Memorandum from AECOM
- Phase 1 Shellfish Tech Memorandum dated June 2015

GENERAL RESPONSE: Thank you for taking the time to review and comment on the Site Characteristics and Evaluation for Aquaculture/Shellfish Propagation Technical Memorandum (Tech Memo). Below are specific responses to your comments.

Summary

1. The reports are focused mostly on Pleasant Bay. Town Cove seems to be dismissed by comparison. Town Cove is far more in need of remediation than Pleasant Bay based on the nitrogen levels shown in Cadmus Report of June 2015 and current nitrogen monitoring data in Town Cove. So the plan is unbalanced. How will it become balanced?

2. Mussels are a historical feature of our Orleans shellfish culture. Again mussels in Town Cove dismissed in the report. Decision was not made with local input .

   RESPONSE: We believe that a key purpose of a shellfish demonstration project is to evaluate the impacts of shellfish propagation or/and aquaculture system on the water quality. For this reason, we are focusing on the areas that are likely to result in high shellfish survival, in order to maximize the potential for quantifying impacts. While we do not want to preclude opportunities to further scientific understandings related to various species propagation, we feel that it is important to focus on already proven approaches for growing shellfish species. We want this first demonstration to work well, so that the ongoing shellfish efforts can build on this success.

   We reviewed the idea of growing blue mussels (Mytillus edulis) in response to your comments and have the following observations:

   - We agree that mussels are an important species to include as part of the mix of shellfish used for nitrogen-removal.
   - We believe that shallow-water propagation of mussels reliably is still at the research stage, making it a higher risk for this project than demonstrating oysters or quahogs.
   - It is our understanding that the mussel bed propagation is difficult in shallow water due to severe predation from sea/bay ducks.
   - Siting can also be an issue, but this is the case with all gear-based aquaculture.
   - Deep-water mussel projects are not applicable to Nauset Harbor because these estuaries are too shallow to prevent ducks from diving to feed on them.
   - Presently, there are no seed mussels available from hatcheries for a demonstration project.
   - Relocating mussels from natural set may not be a reliable/sustainable, long term source for ongoing growth of mussel beds as part of a demonstration.
   - There is limited data on nutrient-removal from mussels, and no data for Cape Cod.

- There is one small mussel grant in Orleans, which we see as an opportunity for future efforts.

- As part of working with growers, mussel aquaculture in Town Cove and Mill Pond should be explored.

- We are not aware of any shallow-water mussel propagation or restoration efforts in New England (which is different from aquaculture efforts), nor published literature that describes a successful methodology for artificially propagating blue mussels on Cape Cod or similar areas. We have spoken to MBL about their efforts near Martha's Vineyard (both blue and ribbed mussels) but we think the blue mussel deep-water aquaculture project is not comparable to the sites in Orleans.

The EXCEL spread sheet with binary scores for all parameters for site selection does not show a thoughtful or correct analysis.

Engineering trade -off decision making relies on expert input to weigh the **importance** of each parameter. The Excel Spreadsheet analysis incorrectly treats every parameter with equal weight. The Excel spreadsheet must be redone correctly by weight assignment to each parameter. Outcomes may change for site selection.

RESPONSE: The shellfish team specifically discussed whether we felt that one factor was more important than another and we all agreed that the factors had equal weight. We believe that our analysis, based on available data for all parameters evaluated was thoughtful and correct. However, we recognized during our analysis that the Town may choose to assigned additional weight to one or more factors.

3. Reference is made to an "Shellfishermen Association directive" that eliminates oysters from consideration in Town Cove. Where is the reference documentation and analysis supporting this decision? Who made it? There are successful oyster grants in Nauset Harbor / Town Cove.

   RESPONSE: This information was presented by Cape Cod Cooperative Extension to the Massachusetts Shellfish Officers Association. The shellfish team confirmed this recommendation with Diane Murphy and Josh Reitsma, and included it in our report.

4. The planned demo by AECOM for Pleasant Bay is poorly explained in the reports. We need more technical detail to assess its efficacy. The Google earth site photo in Pochet is barely legible. What is the purpose, goal and cost of the demo? Please correctly explain what is planned in much greater detail including water flow paths , sampling station locations , monitoring plan and rationale for using commercial shellfish grants as a resource.

   RESPONSE: The purpose of this Tech Memo is to characterize demonstration sites. This is not the engineering plan for a demonstration, which will be the subject of the next Technical Memorandum entitled "Preliminary Engineering Design and Work Plan". Please read our response to the comments received by the Cape Cod Cooperative Extension. In our response, we explained in greater detail why the specifics of a demonstration design will be the subject of this next Tech Memo.

5. How will measured changes in nitrogen be made? Pochet shows a bioactive nitrogen level at one station to be very low and within DEP spec. If nitrogen levels are so low how will it be possible to measure small changes meaningfully? Please consult the 2015 Cadmus Report when considering your answer. Please show similar levels measurements in Wellfleet, Boston or Falmouth or anywhere else in the United States.

   RESPONSE: Shellfish uptake phytoplankton, which can be estimated using empirically-derived chlorophyll-a concentrations. Phytoplankton-derived nitrogen is also contained in the particulate organic nitrogen (PON) fraction of the total nitrogen (TN) measured as part of water quality evaluations. In the datasets for Pleasant Bay, the PON fraction is approximately 25% of the TN. Moreover, a monitoring program for the demonstration locations will be designed to specifically measure localized (in situ) changes in water clarity, pigments (chlorophyll a), and particulate organic nitrogen (PON) as well as total nitrogen. This involves sampling with high temporal and spatial resolution. For example, the Little Pond Demonstration Project in Falmouth measured changes in PON effectively using this approach; as well as in the Wellfleet oyster restoration project. Measuring nitrogen changes where absolute concentrations are below 1 mg/L is not a problem because laboratory equipment is sensitive enough to measure to the μg/L level.

6. What is the estimated cost of removing a kilogram of nitrogen using oysters and quahogs ? We need capital and O&M costs for a full scale deployment ---exclude R&D demo costs. We have seen no backup to support any estimate. We need to compare these cost numbers to Sewering. Are there are nationwide sources and estimates from other Cape towns that provide cost numbers that can be used to help compare estimates of a cost for Orleans. What is the Orleans cost for the demos? **Cost will decide how the citizens support acquaculture remediation.**

   Response: This is an important question but is outside the scope of this Tech Memo. These types of questions will be addressed in the next Tech Memo.

7. The recommended Hybrid Plan is based on obsolete requirements for nitrogen removal that are over a decade old. Nitrogen Levels in Town Cove are 50% higher now than then. **The current Hybrid system design will not restore water quality in Town Cove.** When will the correct design requirements be used so that a correct acquaculture deployment can be designed?

   Response: This is an important question but is outside the scope of this Tech Memo. As part of Adaptive Management, A Technical Memorandum evaluating baseline conditions has been prepared and is currently under review by SMAST.

8. I am disappointed with the lack of accomplishment on the aquaculture project. Tasks scheduled for late 2016 and 2017 should have been already been completed. The Pleasant Bay plan using existing grants and shellfishermen is not scientifically supported in the report. The plan is not quantitative. I am not sure the community will support such a long non specific , fuzzy and expensive plan. Two years pass and not one oyster planted!

   RESPONSE: The purpose of this Tech Memo is only about characterizing the sites. This is not the engineering plan for a demonstration, which will be the subject of the next Tech Memo, once the demonstration locations are selected. Please read our response to the comments from Cape Cod Cooperative Extension. In this response, we explain in greater detail why the specifics of a demonstration design are the subject of the next Tech Memo.

9. Has the Hybrid Plan been revised to reflect the decisions you made for elimination of oysters in Town Cove? What are the new remediation techniques now in the Plan? Do the recent WQAP costs presented reflect the revised techniques?

Response: Oysters have not been eliminated from Town Cove. Town Cove is simply not the preferred location for the first (of likely several) demonstration projects in Orleans. Quahogs are also an important species for Town Cove in the Hybrid Plan.

One excellent suggestion that has come from this review is to evaluate the potential for additional shellfish leases in Town Cove. In this way, oysters could be grown in Town Cove in gear-based systems, thus avoiding the bottom-planting that leads to increased drill populations.

10. Does the DEP agree with the proposed Orleans plan?

Response: This is an important question but this Tech Memo is not the Orleans plan.

11. We know that oysters grow in Town Cove and Pleasant Bay. We know approximately how much nitrogen each oyster removes. Is there a more efficient and cost effective way to calibrate and assess how much nitrogen will be removed by a calculated quantity of oysters at a particular location? For example : 1)by extracting a known small quantity of oysters and water from a location then moving both to a laboratory location and 2) accurately measuring the nitrogen reduction over a predetermined length of time use the data to estimate from that location to estimate nitrogen from that location. I would be happy to discuss this approach further.

Response: Field studies and comprehensive monitoring are critical to evaluating shellfish impacts to water quality because ecosystems are comprised of dynamic and interdependent variables. It is important to remember that shellfish filter water and in the process feed on the organic particles therein. These filtered particles include phytoplankton, suspended silt and clay, and detritus. Most of the particles that oysters ingest are microalgae (phytoplankton), but other particles are also metabolized. The nitrogen bound in organic particles may also be removed by this filtering process. Oysters do not directly remove inorganic nitrogen (nitrate and nitrite).

In addition to removing the fraction of the total nitrogen in the water column that is in organic particles, water clarity and phytoplankton filtration are top-down controls on eutrophication. Therefore, monitoring these parameters in-situ is the best way to understand the value of shellfish for nitrogen-removal uptake, as well as water clarity improvement.

We very much appreciate your comments and questions!

Comments from Dave Slack (in black) and AECOM Shellfish Team Responses (in red) provided below

Thank you for taking the time to review the Site Characterization Technical Memorandum. We appreciate your comments.

1. I'm pessimistic about oyster reef viabiliy in either Nauset or P. Bay. Oysters in our waters love to die under the best of husbandry but particularly when left untended on the bottom. Natural set or recruitment would likely be negligible. To achieve significant N reduction with aquaculture would require thousands of pieces of equipment and hundreds of hours of maintenance. Quahogs doing poorly in much of P. Bay. Few growers currently are even buying Mm seed.

   RESPONSE: We agree that aquaculture is equipment and labor-intensive. Any solution to nitrogen-remediation is going to require a significant effort. We believe that the ecosystems services and economic as well as local food production benefits of shellfish warrant further analysis. In particular, we may find that the filtering of phytoplankton as a top-down control of eutrophication starts to improve water quality immediately. This ecosystems service may reduce the total nitrogen-removal required to achieve water quality.

2. Diane Murphy has studied disease and predation in P. Bay for years. It's brutal.

   RESPONSE: We agree that predation is going to be a major factor in determining how we grow shellfish in Pleasant Bay, and bottom-planting feasibility.

3. Diminished tide flow is disrupting oyster aquaculture in Town Cove. Unlikely that an oyster Demo Project would succeed there.

   RESPONSE: We have not recommended an oyster demonstration in Town Cove. We have heard from growers in Eastham that they have good success with oyster aquaculture, although fouling requires constant cleaning of gear.

4. What is the proposed interaction between existing growers and the Demonstration Project in P. Bay. Successful growers are already maxed out in terms of bottom and time.

   RESPONSE: The proposed interaction is to begin a dialogue to help build an understanding of the practical extent to which shellfish aquaculture can contribute to the town's water quality goals. Working with growers will also help define the needs of this group relative to the town's goals for shellfish.

5. What impact will Demonstration Project have on our already stressed public landings particularly Paw Wah where summer parking and access are already problematic.

   RESPONSE: We agree that access is a key factor in selecting a demonstration location. Your concern about public landings, and not increasing pressure on the limited parking is very important. We will make sure to keep this in mind as we plan the day-to-day logistics of installing and operating a demonstration project. Paw Wah is not being considered because it is currently an area closed to shellfishing.

We appreciate these thoughtful insights.

Comments from Sandy MacFarlane (in black) and AECOM Shellfish Team Responses (in red) provided below:

To: Sia Karplus
From: Sandy Macfarlane, Coastal Resource Specialists
Re: Review of the Technical Memorandum on Draft for Site Characteristics and Evaluation for Aquaculture/Shellfish Propagation
Date: March 4, 2016

You asked me to review and comment on the Technical Memorandum on Draft for Site Characteristics and Evaluation for Aquaculture/Shellfish Propagation.

In order to review this document, I also included earlier communiques including materials sent prior to the Shellfish Forum held in June, Orleans Shellfish Operations and Program Expansion Plan, the Orleans Water Quality Advisory Panel Consensus document and the spreadsheet matrix used to evaluate potential sites.

My comments include ones of both general and specific nature.

Thank you for providing your comments and suggestions to the Technical Memorandum, we appreciate your input to this process.

GENERAL RESPONSE: Please also read our response to the comments from Cape Cod Cooperative Extension. Here, we explain in greater detail why the specifics of a demonstration project design are going to be the subject of the next Technical Memorandum, entitled "Preliminary Engineering and Design Work Plan". We will also note in the Purpose section of the Site Characterization and Evaluation Technical Memorandum that preliminary engineering and design are addressed in a subsequent Technical Memorandum.

General:

1. I was surprised to see that Lonnie's Pond was not considered. At the shellfish forum, terminal ponds were identified as areas in greatest need of nitrogen remediation to meet TMDL's. A plan to address the needs of Meeting House Pond (the most severely degraded waterbody) exists but I have not seen a similar plan for Lonnie's Pond. Lonnie's was mentioned several times as potentially appropriate for certain types of shellfish propagation.

   RESPONSE: Lonnie's is under review for a PRB by the EPA. In addition, Lonnie's was identified in both the Hybrid Plan as well as by the Floating Constructed Wetlands (FCW) team as a preferred location for a FCW. Planning for a FCW demonstration project is proceeding at this site. Therefore, it was not included in the shellfish demonstration site selection. Shellfish could be part of full scale CWMP implementation at Lonnies, even though a first-round demonstration is not planned for this site.

2. The closest site to Lonnie's is the Lower River site at Kent's Point that was rejected (more on that later). With that rejection, Lonnie's is not covered at all from a remediation standpoint. While these are demonstration projects and a full-scale program may emanate from them, choosing sites that may have the most remediative qualities would seem to be appropriate.

   RESPONSE: Please see the Purpose section of this Technical Memorandum (Tech Memo) as well as comments to Cape Cod Cooperative Extension regarding the purpose of this Tech Memo. This is not the overall plan for remediation project. The reasons why Kent's Pond was not selected are based on important considerations.

3. In the pre-forum materials, approximately 17 acres were suggested for shellfish/restoration; in the current document, 13 acres are suggested (5.5 acres in Nauset and 9 in Pleasant Bay). The discrepancy is not explained anywhere that I can find. The memorandum does not contain the final tally of acres or amount of shellfish needed to achieve the stated goal at each site. It is not known if the estimate presented to forum panelists is the same as the amount presented to the advisory panel. Therefore, I cannot comment on the feasibility of the amount of shellfish to be raised. The amount and size of shellfish to be cultured will dictate the type and amount of gear to be used, especially if oysters are considered.

   RESPONSE: Please see the Purpose section of this Technical Memorandum (Tech Memo) as well as comments to Cape Cod Cooperative Extension regarding the specific purpose of this Tech Memo. This is not the overall plan for full-scale nitrogen removal in either Pleasant Bay or Nauset Harbor. The purpose of the current effort is to implement a demonstration project to test different aspects of shellfish propagation or aquaculture at a given location. Quantitative recommendations will be developed through an Adaptive Management process based on the findings of the demonstration projects.

4. Whereas identifying specific sites was rejected in favor of generalized areas, evaluation of specific grow-out methods is not feasible since actual site conditions can vary considerably. (See Macfarlane). Macfarlane, Sandra L., 1998. The evolution of a municipal quahaug (Hard Clam) Mercenaria mercenaria management program: a twenty year history - 1975-1995. Journal of Shellfish Research, Vol. 17(4):1015-1036.

   RESPONSE: The purpose of this Tech Memo is to characterize the sites for demonstration projects. This is not the design and monitoring plan for a demonstration, which is the subject of the next Tech Memo. Please see our comments to Cooperative Extension that explains in detail the process we have been using.

5. The amount of area to be used for each separate demonstration project was listed in the original materials but is not listed in the memorandum. I do not know if they remain the same.

   RESPONSE: The purpose of this Tech Memo is to characterize the sites for demonstration projects. This is not the design and monitoring plan for a demonstration, which is the subject of the next Tech Memo. Please see our comments to Cooperative Extension that explains in detail the process we have been using.

6. The only predator noted in the memorandum is the oyster drill. Both Nauset and Pleasant Bay have far more predators than just one.

   RESPONSE: We agree with your comment, the site characterizations were based on the available data; however, the site engineering and the monitoring plans will include in detail the need for baseline studies and monitoring of disease and predation.

7. Fouling was only mentioned for Nauset. Pleasant Bay would not be immune to fouling at the demonstration sites. The issue of fouling, especially as it relates to gear handling, length of time the gear is deployed, labor needed to address fouling, and eventual cost as a result is not examined to any degree in any of the documentation I have seen.

   RESPONSE: We agree with your comment, but the purpose of this Tech Memo is to characterize the sites. This is not the operation and maintenance plan for a demonstration project, which will be the subject of the next Tech Memo.

8. I cannot find any evaluation of removal of contaminants of emerging concern. They are mentioned once as a potential issue/threat but addressing them is not discussed.

   RESPONSE: Thank you for your comment. This Tech Memo did not address this issue. CECs will be considered for inclusion in the demonstration monitoring plan.

9. I am unsure of how the inventory of potential and existing conflicting uses was executed and the time of year the inventory was conducted.

   RESPONSE: This was accomplished by interviewing the Harbormaster and Shellfish Constable

10. I assume low DO measurements were usually bottom water (although not always specified in words) but the time of year the sampling was conducted is not mentioned. I also assume it was summer measurements when DO should be at their lowest level. If that is the case, shellfish would probably not be grown in the deepest part of the water body where low DO would be most problematic. If that is not the case, DO needs further exploration as a parameter.

    RESPONSE: Your assumptions are correct, DO was bottom water sampled during the summer. Quanset does not have low bottom-water DO. DO assessments will be part of the monitoring plan for each demonstration project.

11. It is unclear on whether eelgrass cover was based on existing maps or was ground-truthed to current conditions. If it was ground-truthed, there is no mention of when that was accomplished.

    RESPONSE: The published eelgrass maps have a degree of ground-truthing already. When we visited the sites by boat and on foot when near the shoreline, we performed visual verification of general presence/absence of eelgrass.

12. How the type and location of current uses of the waterways were determined is not fully explained.

    RESPONSE: This was accomplished by interviewing the Harbormaster and Shellfish Constable

13. How the relative importance of other uses in the numerical scale was determined is not explained. No factor has greater weight and I understand that, but if there were thresholds to get to a positive, neutral or negative scoring, those thresholds were not defined. (See Pleasant Bay Resource Management Plan and Macfarlane et al.).

    Macfarlane, S.L., J. Early, T. Henson, T. Balog, and A. McClennen, 2000. A resource-based methodology to assess dock and pier impacts on Pleasant Bay, Ma. Journal of Shellfish Research, Vol.19, No. 1, 455-464.

    "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 GIS maps from the DMF, preliminary grain size maps from Center for Coastal Studies and notes from site visits with the harbormaster and shellfish constable. The Team then evaluated each demonstration site and ranked the criteria for each site based on this available information."

    Based on the above paragraph, there is no indication of how the separate pieces of the shellfish suitability index, for example, were fitted together to determine the eventual score at each site. The same is true for the other uses of the area that could be conflicting, especially boating.

    RESPONSE: For the purpose of this project, this was accomplished by using the developed Site Evaluation Matrix tool that is attached to this email response.

14. The memorandum states directly that "neighbors are not likely to object to a well-designed demonstration location near them." The origin and veracity of that statement is not explained; who was contacted, what were those people asked, how was the project described, etc.

    RESPONSE: We did not directly contact neighbors. This statement is based on the team's experience implementing other demonstrations and the scale and location being proposed for this demonstration project. As potential demonstration sites move forward, neighbors will be contacted. Part of what a demonstration shows is how people feel about the project. A demo is ideal because it allows for reactions to be based on a real project, and allows for the demo to be discontinued if not acceptable. It is probably more accurate to say that "Neighbors are less likely to object to a well-designed demonstration". We will edit the Tech Memo accordingly.

15. Only two areas are noted for education and outreach and I find that curious, since many of the locations have some attributes for those activities.

    RESPONSE: During our site visits, the areas mentioned seemed to have exceptional attributes for education and outreach and that is why they were called out. We agree that all the sites could have educational and outreach activities.

16. There is no mention of the size of the upweller system that would be needed nor is there any discussion of seed acquisition.

    RESPONSE: This Tech Memo is only about characterizing sites. This is not the operation and maintenance plan for a demonstration. This is the subject of the next Tech Memo

17. Of great important is the follow-up after the demonstration project runs its course. If shellfish are to be utilized as part of a wastewater management plan, it would be an annual expenditure to grow the amount of shellfish needed to offset the nutrient loading, especially if the source of the nutrients is not addressed. Establishing natural shellfish productivity through propagation is possible but it is definitely not a guaranteed success. The numbers needed, despite the prolific nature of shellfish to reproduce, is high; a very small number survive to reproduce in natural conditions (for coastal habitat restoration as envisioned in the memorandum). For planning purposes, shellfish cultivation would have to be a long-term annual commitment. Seed availability and upweller operation annually would be crucial elements as well. Additionally, these are live animals that live in a complex environment where small perturbations, that can easily go unnoticed, can have severe deleterious effects.

    RESPONSE: We completely agree with this statement and budgeting and planning will take these factors into account.

Specific areas:

1. Town Cove is a big body of water shared with Eastham. The map provided with the pre-forum materials showed three demonstration locations near the middle of the Cove. It is unclear where those sites actually are relative to the channel and therefore water depths and sediment types, at those sites are unknown. It is unclear why quahaugs are not considered for an upweller nursery. If I am not mistaken, an area near the Yacht Club is closed to shellfishing during part of the year but is open for family permit holders during the remainder of the year. The matrix spreadsheet does not downgrade the Town Cove because of it being a popular recreational destination. It is a busy place yet without knowing the area under consideration, it is impossible to say whether other uses would conflict (see #13 above).

   RESPONSE: All of Town Cove was considered in the selection process. Because of severe predation for oyster bottom-planting (per Shellfish Constable) and without a population study of existing quahogs, a demonstration here was not recommended as the first step for Orleans. The next Tech Memo will provide recommendations on design and engineering for demonstration projects and will include recommendations for both a quahog population study, and a study of the potential for expanding aquaculture in Town Cove.

2. The reason for rejecting mussels "due to the difficulty of growing this species at this time." The prolific nature of mussels, feeding habits and nature of gregarious setting would seem to be worth some sort of demonstration project.

   RESPONSE: We believe that a key purpose of a shellfish demonstration project is to evaluate the impacts of shellfish propagation or/and aquaculture system on the water quality. For this reason, we are focusing on the areas that are likely to result in high shellfish survival, in order to maximize the potential for quantifying impacts. While we do not want to preclude opportunities to further scientific understandings related to various species propagation, we feel that it is important to focus on already proven approaches for growing shellfish species. We want this first demonstration to work well, so that the ongoing shellfish efforts can build on this success.

   We reviewed the idea of growing blue mussels (Mytillus edulis) in response to your comments and have the following observations:

   - We agree that mussels are an important species to include as part of the mix of shellfish used for nitrogen-removal
   - We believe that shallow-water propagation of mussels reliably is still at the research stage, making it a higher risk for this project than demonstrating oysters or quahogs
   - It is our understanding that the mussel bed propagation is difficult in shallow water due to severe predation from sea/bay ducks
   - Siting can also be an issue, but this is the case with all gear-based aquaculture
   - Deep-water mussel projects are not applicable to Nauset Harbor because these estuaries are too shallow to prevent ducks from diving to feed on them
   - Presently, there are no seed mussels available from hatcheries for a demonstration project
   - Relocating mussels from natural set may not be a reliable/sustainable, long term source for ongoing growth of mussel beds as part of a demonstration
   - There is limited data on nutrient-removal from mussels, and no data for Cape Cod
   - There is one small mussel grant in Orleans, which we see as an opportunity for future efforts

- As part of working with growers, mussel aquaculture in Town Cove and Mill Pond should be explored

- We are not aware of any shallow-water mussel propagation or restoration efforts in New England (which is different from aquaculture efforts), nor published literature that describes a successful methodology for artificially propagating blue mussels on Cape Cod or similar areas. We have spoken to MBL about their efforts near Martha's Vineyard (both blue and ribbed mussels) but we think the blue mussel deep-water aquaculture project is not comparable to the sites in Orleans.

If you are aware of successful efforts, please let us know.

3. Mill Pond is a propagation site. Oysters in bags in oyster condos for the last three years have not been bothered by oyster drills but once they are bottom planted, they are heavily preyed upon. While it may take extra diligence, rejecting Mill Pond because of the drills may not be advisable. Mill Pond and Robert's Cove have, in the past, been high mussel producing areas, a species also preyed upon by drills. A combination of all three species in that area could be beneficial. Moreover, the semi-enclosed nature of the Mill Pond makes it a reasonable candidate to measure the nitrogen reduction capability of the shellfish.

   RESPONSE: We agree that oysters that are bottom planted will be heavily preyed-upon. We also support the polyculture paradigm. For the reasons stated above, we do not believe there is a reliable source of mussels for a demonstration, and are concerned that the sea and harbor ducks would eradicate any mussels before the drills got to them. We do support the implementation of remediation efforts in Mill Pond using gear-based systems. The use of gear-based aquaculture is a well-established practice, and we feel that a demonstration of this technique is not necessary. Instead, we recommend a program that explores working with growers already using gear-based systems. Based on comments, growers in Town Cove will be included in this exploration.

   In terms of finding locations with good potential for monitoring success, shellfish uptake phytoplankton, which can be estimated using empirically-derived chlorophyll-a concentrations. Phytoplankton-derived nitrogen is also contained in the particulate organic nitrogen (PON) fraction of the total nitrogen (TN) measured as part of water quality evaluations. In the datasets for Pleasant Bay, the PON fraction is approximately 40% of the TN, and is about 25% in Mill Pond. A monitoring program for the demonstration locations will be designed to specifically measure localized (in situ) changes in water clarity, pigments (chlorophyll a), and particulate organic nitrogen (PON) as well as total nitrogen. This involves sampling with high temporal and spatial resolution. For example, the Little Pond Demonstration Project in Falmouth measured changes in PON effectively using this approach; as well as in the Wellfleet oyster restoration project.

4. Little Pleasant Bay was set aside as a grant site because of its lack of natural productivity and because it is not in an area of as high in boating activity as other areas. Working with grant-holders for a demonstration project is laudable. However, reliance on private aquaculture to provide a public service of nutrient remediation should be fully examined.

   RESPONSE: We agree that a full examination is necessary, and in the next Tech Memo will detail a program for a full evaluation of this option.

5. Arey's Pond is another terminal pond where remediation is most needed. The accumulation of fine silt and heavy organic mud precludes the pond of being bottom planted as stated. Moreover, the number of boats in the pond limits the amount of floating gear that could be deployed. The area may require further scrutiny. It is not clear why aesthetic considerations are -1 but conflicting use is 0 at this site. The land around the pond is developed but there is a section of undeveloped land and the boating use is very high (again, see #13 above).

   RESPONSE: Ongoing use of floating bags are not considered as a vista-neutral approach, thus the -1 rating. The demo envisioned would be small and outside the boating area, with no real conflict with boating. The replicability is low and the operation and maintenance much more difficult.

6. Pochet is an interesting area to consider. According to the map, the site chosen is in the river heading to the broader area north of Pochet Island. Any part of the broader area has limited use as a demonstration site due to sediment conditions. If the demonstration project is where it is suggested, on the Pochet Island side of the river at the south eastern part of Barley Neck, it would be more or less out of the way but as stated, it would not be easily accessible.

   RESPONSE: Access is tough and requires permission from a private landowener and the National Seashore. With private aquaculture nearby, the team thought that this would make monitoring even more complex.

7. The analysis of Little River is difficult to understand. There is nothing stated to preclude its use for a demonstration project except that it is a popular recreational destination and for that, it has been excluded. It is not clear why aesthetics or user conflicts are determined to be higher at this site than elsewhere. There are more similarities between this site and others than differences.

   RESPONSE: Our understanding from field visits is that this area is very popular for water skiing and outside a ribbon of sand, most of the bottom is muck, which precludes bottom planting. It is these two factors together that ranked it lower than Quanset.

8. Quanset is also difficult to evaluate. All the information provided deals with the pond but the actual site for the work is not clear. If a reef is established in a shallow area of the pond that expands to the very narrow shallow channel, the reef will decrease the depth even more with sharp-shelled oysters. The pond is also a highly-used mooring area. If the reef is on the outside of the pond, as the original map indicates, that is a different situation entirely and it is not clear if a reef does eventually get established, whether it will expand to the shallower parts of this area.

   RESPONSE: This Tech Memo is only about characterizing sites. This is not the operation and maintenance plan for a demonstration. This is the subject of the next Tech Memo.

I hope these comments are useful as Orleans continues to evaluate the possibility of shellfish as part of a wastewater management program. However, shellfish at the end of the effluent trail does nothing to correct the root of the problem—the one that starts with the backyard septic system. Shellfish added to the ecosystem will help but they can't do it all and they are not a panacea.

We very much appreciate your comments and questions!

Sandy requested that these three comments came in via email on March 6, 2016:

First, as a person who no longer lives in the area, I am honored to have been asked to comment.

Second, while not the primary objective, the number of demonstration projects and the diversity of sites will present a positive impression to put shellfish front and center as a resource that provides many benefits. Residents and tourists alike will understand what it takes to get shellfish from the water to the table as well as the ecosystem services they provide. They will also hopefully understand the challenges involved in a long-term project designed to maintain shellfish populations and to establish new populations of certain species. My earlier review points to some of those challenges.

Third, I appreciate the introduction of the matrix approach as a tool to sort through a range of criteria. A little tweaking to define those might be helpful.

We appreciate these thoughtful insights.

Appendix B

Non-Traditional Technology Descriptions – Siting Criteria Limitations and Constraints

NON-TRADITIONAL TECHNOLOGY DESCRIPTIONS, SITING CRITERIA, AND LIMITATIONS AND CONSTRAINTS

BASELINE MEASURES

The DRAFT Cape Cod Area Wide Water Quality Management Plan Update (208 Plan) lists two main baseline measures that could be implemented in all watersheds, including:

- Non-structural source control measures such as fertilizer controls.
- Structural measures related to stormwater management best management practices (BMPs) promulgated through local regulations.
- Both stormwater and fertilizer remove sources of nitrogen from entering waterbodies.
- Timeframe for water quality improvements once implemented depend on distance to impaired waterbodies.

FERTILIZER MANAGEMENT

Technology Description, including information from the DRAFT Cape Cod Area Wide Water Quality Management Plan Update (208 Plan):

- Fertilizer load contributes 6% (1180 kg/year) of controllable nitrogen in Nauset Harbor watershed and 23% (8,135 kg/year) of the controllable load in Pleasant Bay watershed.
- Fertilizer controls are a source reduction strategy for this nitrogen source.
- 208 Plan recommends enforceable regulations and best management practices to reduce this load by 25%
- The cost of implementation is low.

The MEP model and a subsequent review of existing scientific literature and available data for the Massachusetts Department of Environmental Protection concluded that 20% leaching of applied fertilizer (used in the MEP models) was a reasonable rate for Cape Cod soil conditions (Horsley Witten Group Inc. 2009). A recent report prepared for the Cape Cod Commission, entitled “Cape Cod Pesticide and Fertilizer-Use Inventory” found that residential fertilizer use contributes the most to the fertilizer loading to groundwater on Cape Cod (Horsley Witten Group Inc. 2013). According to studies conducted by the golf course industry, leaching rates can be reduced to 10% or less using well-planned fertilization programs.

Best Management Practices (BMPs), education, and local fertilizer regulations will achieve nitrogen reduction. Effective enforcement is important. Unnecessary fertilizer applications are the component that leaches into groundwater. Prohibitions that remove these sources include:

- No fertilizer when grass is dormant
- No fertilizer on imperious surfaces (such as inadvertent application on driveways)
- No fertilizer before heavy rain events
- No over-fertilizing

Using slow-release instead of fast-release fertilizers, and appropriate watering and aerating can increase the health of turf and reduce the need for fertilizer. Transitioning to turf or other ground-cover that is less water and nitrogen-intensive is also useful. The concept of a “Cape-friendly Lawn” branding, and transitioning to other ground cover are seen as important goals for restoring impaired estuaries.

Performance

25% reduction in the nitrogen load (kilograms) attributable to the application of nitrogen from fertilizer.

Local Implementation

Orleans has an approved fertilizer control bylaw with enforceable regulations for the above BMPs. Moreover, this Bylaw prohibits any application of fertilizer within 100' of resource areas as defined by the Orleans Wetlands Regulations. Orleans has also drafted a phosphorus bylaw to accompany its grandfathered nitrogen bylaw, planned for fall 2014 Town Meeting approval. Enforcement through the Town Zoning Enforcement Officer (or designee) is likely to be complaints-driven, as is the case in many communities. This significant regulatory step would be enhanced by educational initiatives. There are a number of local organizations that may take the lead on public outreach and education. County-wide approaches may also be forthcoming.

Limitations and Constraints

- Awareness of and compliance with Bylaw

Next Steps

- Update Orleans Fertilizer Study to more accurately quantify the fertilizer nitrogen load.
- Identify groups that will lead or partner on educational initiatives.
- Notify property owners that are within 100' of resource areas about the bylaw. Town of Falmouth has sent a letter from the Enforcement Officer that can be used as a template.
- Notify lawn service companies about the bylaw. Scott's Lawn has already contacted Falmouth stating that they are identifying all customers with lawns within the areas where nitrogen-application is prohibited to develop lawn management programs that do not use nitrogen fertilizer.
- From the mailing list, and Fertilizer Study Update, quantify the nitrogen-removal benefit of the prohibition against applying nitrogen fertilizer within 100' of resource areas.

STORMWATER MANAGEMENT

Technology Description, including information from the 208 Plan:

- Stormwater load contributes 9% (1770 kg/year) of controllable nitrogen in Nauset Harbor watershed and 13% (4,576 kg/year) in Pleasant Bay watershed.
- 208 Plan recommends Best Management Practices to reduce this load by 25%.
- Stormwater BMPs are a source reduction strategy for both nitrogen, and phosphorous.
- The cost of implementation is moderate when included as part of a larger public works project, and the nitrogen-removal benefits are rapid once the BMP is installed.

There are several stormwater treatment systems that can provide significant nutrient removal capabilities. Vegetated systems such as phytobuffers, constructed wetlands/gravel wetlands, vegetated swales, and bioretention systems are usually engineered to enhance the retention time of storm events. Physical filtration, uptake within plant tissue, nitrification-denitrification, and other microbial biochemical processes are engineered either alone or in series to optimize nutrient uptake and removal. Phytobuffers, also known as vegetated filter strips are uniformly graded vegetated surfaces that receive runoff from adjacent impervious areas, and treat sheet flow or small concentrated flows that can be distributed along the width of the strip. These vegetated filter strips are designed to slow runoff velocities, trap sediment, promote infiltration, and biochemically metabolize pollutants. Water quality swales are vegetated open channels designed to treat water and convey runoff from a 10-year storm without causing erosion. They can be substituted for subsurface piping or open (unvegetated) channels to provide enhanced water quality treatment when constructed in association with other stormwater BMPs. Gravel or other constructed wetlands systems treat different categories of storm events, and are very effective at nutrient remediation because they include separate zones for aerobic (nitrification) and anoxic (denitrification) microbial activity. Depending on the system installed, it is estimated that stormwater BMPs remove 25% - 40% of nitrogen from impervious surfaces.

Performance
25% reduction in the nitrogen load (kilograms) attributable to the application of nitrogen from fertilizer.

Siting Criteria
- Space requirements vary by BMP.
- Orleans has conducted three major planning initiatives for stormwater management (an outfall inventory, an inlets and outfalls loading study, and a mapping initiative). These reports should be used to identify locations for installation of stormwater BMPs that have nitrogen-removal capacity.

Limitations and Constraints
- Life cycle costs
- Practical implementation (where to locate, size of catchment area, overall number of BMPs required to capture stormwater nitrogen and phosphorous loads)
- Actual nitrogen-removal rates given low starting concentrations in stormwater
- Maintenance and management

Pilot Projects on Cape Cod
The Environmental Protection Agency (EPA) has solicited proposals for stormwater BMPs on Cape Cod. Final project selection is expected before the end of 2014. Results of this EPA pilot and other studies should inform future implementation efforts.

INTENSIVE OYSTER AQUACULTURE, OYSTER REEFS, AND QUAHOG PROPAGATION

- Timeframe for water quality improvements (water clarity, nitrogen removal from water column) are within the first year of growth, once shellfish have been installed.
- This is a remediation technology.

Technology Description, including information from the DRAFT Cape Cod Area Wide Water Quality Management Plan Update (208 Plan):
Shellfish are biological filters, consuming the plankton that thrives on dissolved nitrogen and other nutrients in the water. By feeding, shellfish manage the concentration of plankton that continues to regenerate and grow as long as the water is warm. Plankton-removal improves water quality by both removing nitrogen and increasing water clarity. It has also been shown that the waste products of oysters in particular may augment denitrification of bottom sediments, thereby releasing nitrogen in the form of nitrogen gas to the atmosphere. Quahogs (Mercenaria mercenaria) benefit the benthos by hardening soft bottom sediments. According to the 208 Plan, co-benefits of oyster reefs may include habitat provision for juveniles and adults of commercially important fisheries as well as crustaceans (Coen et al. 2007), shoreline stabilization through reduced wave energy (Newell 2004), and increased removal of particulate matter, light penetration, and submerged aquatic vegetation growth, such as eelgrass, due to improvements in water clarity (Golden 2011). It is the synergistic ecologic benefits of nitrogen (and phosphorus) removal, water clarity improvements and improvement of bottom sediments that make shellfish cultivation an intriguing tool for estuaries restoration.

Shellfish aquaculture and reef restoration may also achieve economic and social benefits, in addition to meeting nutrient remediation and ecosystems restoration goals. Shellfish aquaculture and wild harvesting are established industries on Cape Cod, employing many growers and harvesters, and yielding a valuable end product. There are positive economic multipliers from local food production and jobs creation. Oysters are often the shellfish of choice because they are fast growing, and thus incorporate more nitrogen per growing season than other endemic shellfish. Moreover, growing techniques are well-understood and oysters have a relatively high market value. In Orleans, quahogs (Mercenaria mercenaria) are another important shellfish to consider because historically, quahogs have thrived here.

Performance

Cape Cod Cooperative Extension together with Woods Hole Sea Grant found that local Cape Cod oysters contain an average 0.28 grams of nitrogen per harvest size oyster (3 – 3.2", two years of growth). The nitrogen content of cultured off-bottom oysters was found to be slightly lower (0.26 grams/oyster). Mashpee reports 0.50 grams N per 3.5" oyster. Quahogs have slightly lower nitrogen content (0.22 grams of nitrogen per harvest size littleneck at 1" – 1.5", estimated four years of growth). Larger quahogs contain more nitrogen. Growing time for quahogs is twice that of oysters, and the market value is lower.

Oyster density is reported at 2,000,000 oysters per acre of reef in the Wellfleet restoration project. Falmouth's Little Pond Demonstration Project reports 1,250,000 oysters per acre for the first year of growth, with relay and bottom planting for the second year of growth at a density of approximately 1,000,000 oysters per acre. Commercial growers optimizing for a 2" oyster in one growing season have reported that they stock floating bags at lower densities (as low as 200 oysters per bag). Other growers stock at higher densities. The difference in nitrogen-removal is significant if oysters can be grown effectively at higher stocking densities. The range of densities presented in Table 1 is a function of the area being cultivated, the goals of the grower, and the growing method employed. Quahog densities presented in Table 2 are estimated by area and stocking density assumptions, and should be field-verified.

Table 1 and 2 incorporate research findings to date, for planning purposes. Denitrification rates are an important factor in calculating nitrogen-removal by oysters, and must be determined on a site-specific basis.

Table 1: Planning Estimates for Oyster Nitrogen Removal - Shell and Soft Tissue Only

Size Class	# oysters per bag MAX	Nitrogen removal (g/oyster)	# bags per acre	# oysters per acre at max oysters per bag	N Removal per Acre @ max oysters per bag (kg)
1"	1500	0.008	1200	1,800,000	15
1.5"	1000	0.019	1200	1,200,000	22
2"	500	0.067	1200	600,000	40
3"	200	0.260	1200	240,000	62
3" (at avg N)	200	0.280	1200	240,000	67
3" (at avg N)	400	0.280	1200	480,000	134
3" (bottom/reef)	NA	0.500	NA	1,000,000	500
Denitrification					

Table 2: Planning Estimates for Quahog (Mercenaria mercenaria) Nitrogen Removal - Shell and Soft Tissue Only

Size Class	# quahogs Planted	# quahogs harvested	Nitrogen removal (g/quahog)	N Removal per Acre (kg)
1" thick (Littlenecks)	1,000,000	800,000	0.08	64
2" thick (Quahogs)	1,000,000	800,000	0.24	192
4 years to grow				

Screening Criteria for Shellfish Propagation

- Biologically suitable areas for a range of growing methods:
  - Quahog growth in upwellers for eventual bottom propagation
  - Oyster off-bottom culture (individuals and spat-on-shell)
  - Oyster bottom culture (individuals and spat-on-shell)
  - Oyster Reefs
  - Coastal Habitat Restoration
- Suitable areas that do not conflict with current uses (boating) in terminal ponds and estuaries
- Suitable areas from a regulatory perspective
- Costs associated with management and logistics
  - Private versus public
  - Predation control
- Public acceptance (aesthetics of floating aquaculture equipment)
- Impact of climate change, rising water temperatures and ocean acidification on growth of shellfish, and future changes in predation and disease patterns

Key Permitting Authorities

- MassDEP – for TMDL-compliance credit
- USEPA – for TMDL-compliance credit
- Division of Marine and Fisheries (DMF)
- US Army Corps of Engineers through permit issued to the Commonwealth of Massachusetts (DMF)
- Board of Selectmen
- Harbormaster/ Shellfish Constable
- Department of Public Works (possible)
- Conservation Commission (possible)
- Pleasant Bay Area of Critical Environmental Concern may create other permitting requirements.

Next Steps - Quahogs:

To determine the feasibility of different shellfish scenarios in Orleans, the following are currently being reviewed:

- Current locations of quahogs (present/future)
- Current harvest of quahogs
- Carrying capacity (density) of quahogs per acre in Orleans
- Review results of propagation program in the 1990's (different terminal ponds were studied)
- Review operational needs

Next Steps - Oysters:

- Current nitrogen-removal benefits of Pleasant Bay Shellfish Grants
- Density (optimized) of oysters per acre growing in cages to harvest size in Orleans currently
- Denitrification rates under Grants
- Feasibility/acceptability/water quality benefits of "No Take" zones for spawn and nitrogen removal
- Feasibility/acceptability of harvested reefs for spawn and nitrogen removal
- Additional locations for oyster reefs, oyster aquaculture and quahog propagation
- Discuss Virginia Oyster Gardeners model for possible implementation in Orleans (terminal ponds/docks). 300 oysters/bag x 3300 bags = ~1M oysters)

Limitations and Constraints

- Life cycle and monitoring costs
- Practical implementation (where to locate, size of growing area, risk management)
- Conflicting uses of water (boating, aesthetics) for gear-based operations
- Actual nitrogen-removal rates for different growing systems
- Maintenance and management – significant effort

Pilot Projects on Cape Cod
Wellfleet, Mashpee, and Falmouth are conducting pilot projects. The results of these projects have been incorporated into the planning estimates provided. Orleans has a number of active private growers with Shellfish Grants. The current and potential future production of these operations and their water quality benefits is under review.

PERMEABLE REACTIVE BARRIERS – TRENCH METHOD, INJECTION WELL METHOD

- Timeframe for water quality improvements (reduced nitrogen concentration of groundwater) could be within one year, but depends on the groundwater flow rate, residence time in the barrier, mobility of the treatment, distance of PRB from impaired waterbody, and other factors.
- PRBs are a source-reduction technology (nitrogen does not enter the waterbody).

Technology Description, including information from the DRAFT Cape Cod Area Wide Water Quality Management Plan Update (208 Plan):
A permeable reactive barrier (PRB) is a subsurface zone of reactive material designed to intercept and remediate contaminated groundwater. Utilizing different reactive media, PRBs have historically been used to treat groundwater contaminated by a broad range of contaminants including chlorinated solvents, arsenic, chromium, nitrate and other organic and inorganic compounds (US EPA 2012). Two types of PRB installations are discussed: trench and injection wells.

Trench PRBs
Trench PRBs designed for removal of nitrogen may be comprised of a media (such as wood chips or sawdust) that provides a readily biodegradable carbon source for use by denitryfing bacteria. Generally, trenches are constructed vertically, perpendicular to groundwater flow, in order to intersect and treat horizontally flowing groundwater. A funnel-and-gate configuration may also be used in conjunction with low-permeability materials to direct (funnel) groundwater towards a permeable treatment zone (gate). A trench-style PRB is typically excavated to a certain thickness and depth, determined by the desired treatment zone and the retention time. Then the trench is filled with a media (carbon source) that facilitates denitrification. The practical maximum depth that can be achieved with typical trenching equipment is 40 – 45 feet.

Injection Well PRBs
An injection well PRB is a network of wells by which a carbon source is injected in to the subsurface where it reacts with contaminated groundwater. There are a wide variety of carbon sources that have been used successfully in the field, such as emulsified vegetable oil (EVO), guar gum, fructose, corn syrup, molasses, methanol and ethanol. The injection wells are spaced to provide overlapping radii of influence (ROI) to create a continuous reactive zone. Spacing is determined on a site-specific basis and depends on site hydrogeology and design objectives. Radius of influence is usually a function of soil permeability. Glacial outwash and moraine areas often have variable permeability, depending on the amount of fine fraction in the soil. First order estimates for spacing of borings prepared for the Town of Falmouth suggest a distance of 20-25 feet apart, having a radius of influence of 12-15 feet from each injection point (PRB Technical Memorandum 5b). Injection wells installation methods are able to achieve maximum depths much greater than 40 – 45 feet.

Injection well technology is well-understood, having been used extensively to remove a wide range of contaminants from soils. At a recent workshop on PRBs sponsored by the Environmental Protection Agency, details regarding injection well technology were presented. Of note is that nitrogen species are routinely reduced, as this must occur before microbial activity acts on perchlorate.

Performance

Based on research conducted as part of the 208 Plan Update, the Cape Cod Commission's Technology Matrix provides removal rates for PRBs ranging from 70% to 99% of the nitrate in the groundwater that is intercepted. An extensive literature and regulatory technical review was recently conducted for the Town of Falmouth as part of its PRB Demonstration Project. Based on this work, the recommendation was made to assume 80% nitrogen-removal for planning purposes (PRB Technical Memorandum 5b, CDMSmith). Actual removal depends on the reducing conditions, and how much ammonia is generated and not adsorbed.

Downgradient impacts of PRBs (anaerobic byproducts such as methane, manganese, sulfide, and ferrous iron) may be generated by both trench and injection well PRBs. Understanding these interactions is a critical part of the evaluation process. Potential effects of the PRB to water quality such as increasing concentrations of iron and other constituents are reviewed as part of laboratory (bench) and field analysis prior to installing a PRB. When flow conditions and dosing requirements are well-understood, carbon sources have be injected for groundwater remediation in a way that does not result in surfacing or other downgradient impacts.

In terms of longevity, Trench PRBs have operated for over 10 years. A widely-recognized study conducted in Ontario, Canada showed that only 3% of the wood chip-based carbon source had been metabolized over a seven-year test period, suggesting that the longevity of this system could extend for decades (Robertson 2000). Injection well PRBs require rejuvenation, the frequency of which is best determined by a bench scale test, as well as a field scale pilot study.

To determine the mass or load of nitrogen that will be treated by a PRB installation, the groundwater capture zone must be determined. There are multiple methods to estimate and model the capture zone using water table/groundwater flow direction maps, groundwater flow and contaminant transport models, aquifer properties and analytical solutions. One method, the WatershedMVP planning tool, enables septic capture areas to be defined and nitrogen load reductions to be calculated. Evaluation tools will require field confirmation using site-specific data. Of note is that the WatershedMVP only includes septic load in its calculations, but a PRB also captures any upstream fertilizer and stormwater load that enters the groundwater.

Screening Criteria for PRB Installations

- Publicly-owned locations (roadways or public rights of way). The Selection Criteria mapping tool developed as part of the 208 planning process shows a number of locations where depth to groundwater is less than 20', including areas around terminal ponds, and along The River. However, these areas have private property down to the water's edge. For planning purposes, it has been assumed that siting a PRB demonstration project in public locations is preferred.
- PRB location intersects a groundwater plume with high nitrogen concentrations (downstream of high density development, perpendicular to groundwater flow)
- Access for construction/ sites available up gradient and down gradient for monitoring
- As a secondary screen, review depth to groundwater to determine whether costs are impacted significantly by greater depths

General Installation Considerations

- Vertical thickness of the groundwater lens (thickness of the aquifer to reach saltwater interface). Penetrating at least 20 feet of saturated aquifer thickness is desired, depending on groundwater flow rate
- Matching or exceeding the hydraulic conductivity and permeability of the surrounding groundwater matrix
- Extent of utility conflicts during installation (trench PRB)
- In general, the injection well PRB can be installed in areas with steeper topography than a trench PRB.

- In general, the injection well PRB can be installed in areas where utilities limit the installation of trench PRBs.

Key Permitting Authorities

- U.S. Army Corps of Engineers (USACE)
- USEPA
- MassEPA Unit
- MassDEP
- Massachusetts Division of Fisheries and Wildlife (DFW)
- Massachusetts Historic Commission (MHC)
- Cape Cod Commission
- Conservation Commission
- Planning and Zoning (earthmoving)
- Landowner permission if not a town road

Limitations and Constraints

- Life cycle and monitoring costs
- Practical implementation (where to locate, risk management)
- Actual nitrogen-removal rates
- Maintenance and management

Next steps for implementation of Modified 208 Plan Recommendation:

- Compile additional irrigation well data, if available
- Begin with bench scale tests and field investigations, to determine whether pursuing a Demonstration Project (less than 1000 linear feet) is worthwhile

Planning a Demonstration Project involves two main analytical steps, including (1) bench scale tests and (2) field (pilot) investigations. Bench scale tests are used to evaluate soil demand for a reducing agent, and groundwater chemistry such as dissolved oxygen, sulphate, pH, and other constituents, in addition to nitrate. Field investigations enable collection of data on soil types, stratigraphy, groundwater flow, hydraulic conductivity and other parameters. Fluorescent tracer tests can be conducted as part of initial field investigations to evaluate the radius of injections, and rate of carbon solution consumption (reinjection rates). The type of carbon source can also be optimized during both the bench scale and field investigations. The decision to employ injection wells versus trench PRBs will also be made after field investigations because this choice depends on depths, flow rates and potential for plugging. Based on these two analytical steps, the nitrogen-removal rates, as well as cost of installation, monitoring, operation and maintenance can be accurately estimated. Moreover, potential issues can be identified.

NOTE: 208 Plan recommendations for PRBs in Eastham (Salt Pond, Minister's Pond) have not been evaluated as part of the Orleans CWMP update.

Pilot Projects on Cape Cod

The Town of Falmouth completed a feasibility analysis for PRBs, with an extensive literature review and siting criteria. The screening criteria proposed above are based on the work in Falmouth, as well as additional research by the Cape Cod Commission. EPA Region 1 recommends piloting injection well and trench PRBs to determine their potential effectiveness for removing nitrogen loadings on Cape Cod.

FERTIGATION WELLS

- Timeframe for water quality improvements once implemented depend on travel time to impacted waterbody.
- Fertigation is a source reduction technology (reduces fertilizer use, plant uptake of nitrogen), with co-benefit of drinking water conservation

Technology Description, including information from the DRAFT Cape Cod Area Wide Water Quality Management Plan Update (208 Plan):
Fertigation refers to a system that uses irrigation wells to capture nitrogen-enriched groundwater and deliver it to plants for both watering and fertilization. By using reclaimed wastewater, a fertigation system captures the fertilizer benefit of nutrient-containing effluent in addition to conserving drinking water. Because turf takes up nitrogen, fertigation can significantly reduce nutrient loads to downgradient surface waters as well as reduce fertilizer costs and potable water use. High concentration groundwater is often found at the discharge sites of wastewater treatment facilities, sewage disposal areas, golf courses, areas of dense development with septic systems, and other facilities with large septic systems. Irrigated turf areas include golf courses, athletic fields and lawns.

Performance
The DRAFT Cape Cod Area Wide Water Quality Management Plan Update (p. 3-18) estimates that the nitrogen load reductions for turfgrass areas (such as golf courses, athletic fields or lawns) is 3.8 kg/acre-year. This planning estimate is based on a groundwater nitrogen concentration of 5 mg/L and water use records for managed golf course operations on Cape Cod. The mass of nutrients removed by fertigation is the product of the concentration of nitrogen in the groundwater, and the volume of water used. The reduction in nitrogen load of a fertigation system in Orleans would be calculated using actual water use data and fertilizer application records for the end user, as well as measured groundwater nitrogen concentrations.

Screening Criteria for Fertigation Wells
- Groundwater sources near areas where irrigation and fertilization occur
- Confirmed nitrogen concentration in groundwater at 5 mg/L minimum
- Fertilizer application rates that would be replaced by a fertigation system
- Monitoring of plant uptake of nitrogen, as opposed to reintroduction into groundwater

Key Stakeholders/Permitting Authorities for Fertigation Wells
- MassDEP
- USEPA
- Board of Health
- Conservation Commission
- Land Owner(s)
- Department of Public Works

Pilot Projects on Cape Cod
Case study from the 208 Plan:
The Pinehills golf course community in Plymouth installed a series of fertigation wells downgradient of the discharge site of its wastewater treatment plant. The pumped water is distributed to the golf course, reducing the amount of other fertilizer that is applied. During a two-year monitoring period an average of 434 kg N/year was reused. EPA Region 1 recommends piloting fertigation wells to determine this technology's potential effectiveness for removing nitrogen loadings on Cape Cod.

INNOVATIVE/ALTERNATIVE SEPTIC SYSTEMS

- Timeframe for water quality improvements once implemented depend on travel time to impacted waterbody.
- I/A Septic Systems are a source reduction technology

Technology Description, including information from the DRAFT Cape Cod Area Wide Water Quality Management Plan Update (208 Plan):

Single Unit Systems

Innovative and Alternative (I/A) septic systems collect and treat wastewater from individual dwellings, or commercial buildings and discharge it on the same lot. I/A systems are designed to remove more nitrogen than Title 5 septic systems and often include pumps, aerators, fans and other mechanical parts. Some I/A systems have provisions for chemical addition (pH adjustment and carbon source) increasing microbial denitrification in the unsaturated soils. There are numerous I/A system designs. However, there are only a few approved by MassDEP for the removal of nitrogen. When estimating nitrogen concentrations being discharged to groundwater, Title 5 systems are assumed to have a discharge concentration of 26.25 mg/L. This concentration includes all denitrification that occurs in the wastewater within the septic system and in the unsaturated soils as it reaches the water table. I/A systems achieve lower discharge nitrogen concentrations, but require a higher level of maintenance and are often more expensive to construct, operate and maintain than Title 5 septic systems. In terms of nitrogen-removal performance, I/A systems exhibit a range:

- Title 5 System – assumed discharge concentration of 26.25 mg/L
- Standard I/A System – Mass DEP approval to meet 19 mg/l effluent total nitrogen
- Enhanced I/A System – Mass DEP approval to meet 13 mg/l effluent total nitrogen
- Advanced I/A System – anticipated to routinely meet 5 - 12 mg/l effluent total nitrogen

Cluster I/A Systems

A single-stage cluster I/A system treats wastewater flows greater than 2,000 gallons per day. Subdivisions, apartments, condominiums, or businesses commonly employ cluster I/A systems. Nitrogen levels are typically treated to less than 15 mg/L. Two-stage cluster I/A systems also treat flows greater than 2,000 gallons per day, but include a separate denitrification stage. These systems may require chemical inputs, and an operator to monitor and run the system. Nitrogen levels are typically reduced to between 5 - 8 mg/L. Disinfection may be required as part of cluster I/A systems if the discharge is located within a Zone II of a public water supply well.

Screening Criteria for I/A Systems

- Lower density development
- Suitable hydrogeology
- Land area available
- Other permitting criteria can be met

Key Permitting Authorities for I/A Systems

- MA DEP – TMDL-credit
- Board of Health
- Pleasant Bay Area of Critical Environmental Concern may create other permitting requirements.
- For cluster I/A systems: other permitting authorities if system is part of a new construction project

Limitations and Constraints

- Reliable nitrogen-removal rates (tradeoff between cost and performance)
- Life cycle and monitoring costs
- Practical implementation (where to locate)

Pilot Projects on Cape Cod

The Alternative Septic System Test Center located at Joint Base Cape Cod is currently testing a number of I/A systems, including a non-proprietary "passive" design. In addition, the Test Center has an online database that lists the performance of every I/A system installed on Cape Cod. To use an I/A system not yet approved by MassDEP for nitrogen reduction, the system must go through an approval process. Proven, reliable nitrogen removal is a critical factor in the rating and approval process. Details of the I/A approval process, I/A system designs, and approved I/A systems are provided at the following MassDEP website: http://www.mass.gov/eea/agencies/massdep/water/wastewater/septic-systems-title-5.html#1 . In addition, the Town of Falmouth in collaboration with the Buzzards Bay Coalition has applied for a grant from to install at least 10 I/A Systems on shorefront homes in West Falmouth Harbor. Grant awards are expected in October.

ECO-TOILETS

- Timeframe for water quality improvements once implemented depend on the travel time to the impacted waterbody.
- Eco-Toilets are a source reduction technology

Technology Description, including information from the DRAFT Cape Cod Area Wide Water Quality Management Plan Update (208 Plan):

Eco-toilets separate human feces and urine from the wastewater system of a house or business. Once this source separation occurs, it is able to be composted on-site, or treated in a centralized facility. These human-derived components are then useable as a soil amendment that is rich in nutrients. There are significant environmental advantages to such a system including:

- Eco-toilets divert the nitrogen that is in the feces and urine, so it does not enter groundwater. This decentralized approach replaces traditional wastewater management methods that are capital and resource intensive.
- Eco-toilets use minimal amounts of energy to operate, in most cases a 5-watt exhaust fan for venting is the only energy requirement.
- Water supply infrastructure and current plumbing paradigms first treat water to drinking water standards, then pipe it to homes where thousands of gallons per person per year are flushed down the toilet. This use of drinking water is wasteful of significant amounts of financial and energy resources. Eco-toilets replace this costly approach with technologies that do not use large amounts of drinking water to flush human excrement.
- Human feces and urine can be composted, or treated in other ways, and then used as fertilizers and soil conditioners that are rich in a wide variety of micro and macro nutrients. This conserves valuable natural resources, particularly phosphorus.

Eco-Toilet Technology Descriptions, including information from the 208 Plan

Eco-toilets include composting, urine diverting, incinerating, and packaging toilets and are typically coupled with a conventional system for gray water disposal systems (sinks, showers, baths, dishwashers, and washing machines). Composting toilets can either be self-contained, or have remote bins that hold the compost. Installation, operation, and maintenance manuals for each of the eco-toilets described below are available on the manufacturer's website

The energy use of the fans and heaters associated with each individual composting eco-toilet ranges from 120 to 540 watt-hours per day, or between 44 and 197 kilowatt-hours per year. Urine-diverting fixtures that discharge into a holding tank do not have any fans/heaters associated with them at present. However, the energy used to transport the stored urine should be considered. This will vary by distance.

Self-Contained Toilets

Self-contained toilets are not connected to household plumbing. These fixtures are easy to install, and are particularly useful in places where it is not feasible to connect the existing toilet to a central composting system. Such toilets are often found in basements, or where there is no space available for a central composting unit.

The following units have obtained Product Acceptance from the Massachusetts State Board of Plumbers and Gas Fitters and are approved alternative systems under 248 CMR 10.10:

- Envirolet/Santerra Green: A stand-alone composting toilet in which urine and feces are composted in the same built-in rotary composting unit. Compost is emptied by hand, typically at intervals of four to six months, depending on use. Various models are available. All Envirolet 120VAC electric models use a maximum of 540 watt-hours per day. 120VAC models have two 20W fans and one 500W heater. For more information, see www.envirolet.com .
- Sun Mar self-contained unit: A stand-alone composting toilet in which urine and feces are composted in the same built-in rotary composting unit (biochamber). Compost is emptied by hand, typically at intervals of four to six months, depending on use. Various models are available. Electricity use is 125 watts/day. (includes fan and heater, and assumes 50-percent operation) For more information, see www.sun-mar.com.
- BioLet: A stand-alone composting toilet in which urine and feces are composted in the same built-in rotary composting unit. Compost is emptied by hand at intervals. Various models are available. For more information, see www.biolet.com.

The following units require special permitting from the Massachusetts State Board of Plumbers and Gas Fitters.

- Separett: A stand-alone urine diverting toilet normally set up for hand disposal of both urine and feces that must/will be composted outside the home. The urine chamber of the Separett may also be connected to a large urine tank. For more information, see www.separett.com.
- EcoJohn incinerating toilets: These sewage waste combustion systems process both black and gray water. They are completely self-contained and operate without being connected to any septic or sewage systems. Energy requirements are significant. A small amount of sterile ash is produced. For more information, see http://ecojohn.com/index.html

The following unit can be used in conjunction with a composting system that has Product Acceptance.

Pacto Toilet: Urine and feces collected together in a sealed plastic sack that can be taken out of the toilet periodically and taken to a composting facility. Requires no electricity or bulking agent. For more information, see www.pacto.se, and Appendix 3-5.

Composting Toilet Systems with Remote Composting Bin(s)

Composting Toilet Systems with Remote Composting Bin(s) may consist of a central composting unit with either a single chamber, or a series of chambers filled consecutively. Multiple interchangeable composting units are also available. Composting systems can typically accommodate one or more toilet fixtures. Several different types of toilet fixture may be used. Waterless (dry) composting toilet fixtures as well as waterless (dry) urine-diverting fixtures are typically used when a bathroom toilet can be located directly above, or nearly above the composting unit.

Human waste is moved by gravity through a 10- to 14-inch diameter pipe, from the toilet fixture into the composting unit. Foam flush, micro flush, and vacuum flush toilet fixtures can be used in locations that are not directly above the central composting unit. Some composting toilet systems require connection to a water supply.

The following units have obtained Product Acceptance from the Massachusetts State Board of Plumbers and Gas Fitters and are approved alternative systems under 248 CMR 10.10:

- Advanced Composting Systems (ACS)/Phoenix: Up to four toilets may be connected to a single composting container. Several types of toilet may be connected to the central composting container. Normally the toilet fixture will be a single chamber type with a wide opening through which both urine and feces are transferred to the composting container and processed into compost. A urine diverting dry toilet may also be used with a separate connection to a large urine storage tank. In difficult situations where a toilet is too far away from the composting container, a foam flush toilet may be used. A dedicated vent stack must be installed. The system requires a 5-watt fan that runs 24 hours/day = 120 watt-hours per day. For more information see www.compostingtoilet.com.
- Clivus Multrim: The manufacturer recommends that only single chamber toilets that transfer both urine and feces to the central processing unit be used. Clivus Multrim markets its own foam-flush toilet (Neptune) for situations where the toilet is too far away from the composting chamber for gravity discharge to the compost bin. A dedicated vent stack must be installed. The system requires a 5-watt fan that runs 24 hours/day = 120 watt-hours per day. For more information see www.clivusmultrum.com.
- Envirolet/Santerra Green Central Units: Both direct-discharge dry toilets, as well as vacuum flush units are available. Several toilets may be connected to a single composting container. A high capacity double tank is also available. FlushSmart™ VF™ is a vacuum flush and composting toilet system combination that is recommended for installations on rock or with little or no room below, basements, garages, workshops, pool cabanas, yurts, and applications where a smaller toilet is needed or desired. A dedicated vent stack must be installed. Central models use a maximum of 540W per day. A detailed description is provided in the technical description of the self-contained unit. For more information, see www.envirolet.com.
- Sun Mar Central Units: Several dry toilets may be connected to a single composting container. For locations where a direct gravity feed is not feasible, the manufacturer recommends use of a Sealand 510 or 511 marine toilets. This is an ultra-low flush toilet that may be installed either directly above or up to 15-feet away from the central composting unit. A dedicated vent stack must be installed. Electricity use is 125 watts/day (includes fan and heater, and assumes 50-percent operation).For more information, see www.sun-mar.com .
- Eco-Tech Carousel: Several types of composting toilets, including urine diverting dry toilets and foam flush toilets, may be connected to this set of bins in a rotating chamber. The urine diverting toilet will require connection to a large urine tank and the foam flush toilet must be connected to the household water line. There are two sizes of rotating chamber and each rotating chamber has four separate bins, only one of which is in use at a time. This system requires a 5-watt fan that runs 24 hours/day = 120 watt-hours per day. For more information, see www.ecological-engineering.com/carousel.html.

The following unit requires special permitting from the Massachusetts State Board of Plumbers and Gas Fitters.

- Full Circle: A 55 gallon wheelie bin is connected to a single dry composting fixture with urine-diversion. The bin collects feces for composting, with a separate storage container for urine. Each bin serves only one toilet. A dedicated vent stack must be installed for each bin. For more information, see www.fullcirclecompost.org.
- EcoJohn incinerating toilets: These sewage waste combustion systems process both black and gray water. They operate without being connected to any septic or sewage systems, and the incinerating unit can be located remotely (away from the toilet). Energy requirements are significant. A small amount of sterile ash is produced. For more information, see http://ecojohn.com/index.html

Summary of the Toilet Fixtures used with Composting Systems

Worldwide, many toilet fixtures are being produced for use with composting systems. Manufacturers specify which toilet fixtures are compatible with their composting systems.

- Dry composting toilets (with and without urine-diversion) are installed as part of a composting system. See manufacturer's recommendations for dry composting fixtures that are compatible.
- Ultra-low Flush Composting Toilets: The Sealand 510 and 511 models are the only examples mentioned, and they are recommended for use on Sun Mar central units where toilets must be offset from the central unit.
- Foam Flush Toilets: These function and look much like conventional toilets. Using a mix of biocompostable soap and water, the foam-flush moves waste through a 4-inch pipe to a composting tank below. The foam mixture cleans the toilet bowl with every flush but uses only about three ounces of water, making it fully compatible with the composting process. Since the foam flush is using water to carry the waste, toilets can be offset by up to 45-degrees from the composting bin. This facilitates installations where there is not space for a composting bin directly under a current fixture. These toilets are connected to a home's water supply.
- Vacuum Flush Toilets: The flushing action on these fixtures opens a valve in the toilet, enabling the contents of the toilet to be sucked with pressure, instead of gravity alone. There are a number of different types of vacuum toilets, ranging from toilets connected to vacuum sewer systems to toilets with a vacuum assist, which creates pressure to help flush the contents of a toilet with minimal water usage. Vacuum toilets are common on airplanes and are also used on boats and in personal homes. Because the vacuum involved can exert a substantial force, a vacuum toilet requires little to no water. Some use sanitizing liquids instead of water to keep the toilet relatively clean. Vacuum toilets are often very low-odor.

Urine-Diverting Flush Toilet Systems

Urine-diverting (UD) flush toilet systems connect to the household water and wastewater systems. Each toilet bowl has two chambers, one for feces and toilet paper and the other for urine. The urine chamber is connected to a large urine tank, the larger chamber to the household wastewater line. The following units have Test Site Status from the Massachusetts State Board of Plumbers and Gas Fitters for the demonstration. Up to 40 test sites have been authorized. The urine-diverting tanks are typically installed outside the home, and must be DEP-approved septic tanks with provision for pump-out and sealed against air intrusion. The entire UD system must be installed by a licensed plumber to ensure there is proper venting and traps. A key concern is to avoid blockages and odors from the urine line.

- Dubbletten "double flush" toilet: The urine and feces/toilet paper chambers flush separately, the urine chamber with very little water. The user need not flush the urine chamber after every use. To save water, it is recommended that paper used after urinating is disposed of in a separate receptacle near the toilet, and not flushed. For more information, see www.dubbletten.nu.
- Wostman Eco-Flush toilet: The urine and feces/toilet paper chambers flush separately, the urine chamber with very little water. The user need not flush the urine chamber after every use. To save water, it is recommended that paper used after urinating is disposed of in a separate receptacle near the toilet, and not flushed. For more information, see http://wostman.se/en/.
- Aquatron Centrifuge composting system: Wastewater from the feces/toilet paper chamber of one or more urine diverting toilets passes through a gravity-driven centrifuge that separates solid matter from wastewater going to the septic system. Solid matter drops out into a composting container. The Aquatron centrifuge may be used with any flush toilet, but for our demonstration it will be used with urine diverting flush toilets such as the Dubbletten or Wostmann toilets. For more information, see www.aquatron.se/index-2.php.
- Waterless (or very low flush urinals): There are many models that may be used in conjunction with UD toilets in any UD system. Any fixture that has Product Acceptance may be installed.

Urine Tanks Used with Urine-Diverting Toilets and Waterless or Ultra-Low Water Urinals

Any MassDEP-approved septic tank may be installed as part of the demonstration to hold urine. Tanks with a 500-gallon capacity are being used in the demonstration.

Installation of Eco-Toilets

In most cases, installing composting and urine diverting toilets in existing homes requires modifications to existing plumbing and venting. Space constraints are an important consideration, and sometimes bathroom remodeling is required. Building permits must be granted for these changes, and plumbing work must be code-compliant and be done by a licensed plumber. Any plumbing fixture installed in Massachusetts must have a Product Acceptance number. Several composting toilets have this approval. However, urine-diverting fixtures, source separators (such as Aquatron), and other pilot-stage urine-diverting and composting toilet technologies do not currently have a Product Acceptance number from the Massachusetts State Board of Plumbers and Gas Fitters (MSBPF), and are therefore illegal to install in the state. In order to install equipment that is not already approved, special permitting from the MSBPGF is required.

Selecting the best eco-toilet system is an iterative process involving the physical constraints of the built environment as well as cost and ongoing maintenance considerations. A site visit from someone capable of making these kinds of assessments is a critical component for many people, providing unbiased information on the full-range of eco-toilet configurations and the maintenance requirements that should be expected once an eco-toilet is installed. In addition, plumbers do not have a lot of experience installing these technologies. A Technical Coordinator to work with property owners, plumbers and regulators during the selection and installation process is necessary.

All eco- toilets require some form of residuals management. This is generally performed by a licensed septic hauler. Urine diverting toilets require the removal of urine from a holding tank. The compost and leachate from composting toilets requires periodic removal. Leachate is the excess liquid that is not taken up during process of composting. Leachate is very high in nitrogen and phosphorus; volumes produced range from <1 – 4 gallons/month/person. Incinerating toilets have a small ash residual requiring removal. Packaging toilets will also require frequent residuals removal.

The Town of Falmouth is conducting two demonstration projects related to eco-toilets to determine the nitrogen removal capabilities, cost, installation logistics, operations, and public acceptance of a broad range of composting and urine-diverting systems. Test Site status from the MBPGF for equipment that did not have Product Acceptance was obtained. Data from these Demonstration projects is still being collected. For planning purposes, a residential household which converts all toilets to approved eco-toilets will be removing nitrogen equivalent to an Enhanced or Advanced Innovative/Alternative septic system.

Limitations and Constraints

- Life cycle and monitoring costs
- Public acceptance
- Practical implementation (how to retrofit in homes with more than one bathroom)
- Handling of residuals (compost, leachate and urine)

Screening Criteria for Eco-Toilets

- User acceptance
- Title 5 septic system for grey water (sinks, dishwashers, showers, baths, laundry)
- Feasibility of retrofitting plumbing and making floor area modifications for eco-toilet based on site-specific conditions
- Plumbing board approval for desired technology
- Areas near freshwater ponds due to enhanced ability for phosphorus removal

Key Permitting Authorities for Eco-Toilets

- Board of Health
- Building Department
- State Board of Plumbers and Gas Fitters for Product Acceptance

- Pleasant Bay Area of Critical Environmental Concern may create other permitting requirements.
- MA DEP – TMDL-credit

Pilot Projects on Cape Cod
The Town of Falmouth has initiated two significant demonstration programs for eco-toilets. Results from the installation of the first 6 - 10 systems are expected by the end of 2014.

INLET WIDENING

- **Inlet widening is not being proposed as part of the Orleans Non-Traditional Bookend.**

The following technology description is included for completeness:

Technology Description, including information from the DRAFT Cape Cod Area Wide Water Quality Management Plan Update (208 Plan):
Inlet widening involves the re-engineering and reconstruction of a bridge or culvert opening to increase tidal flow. Maintenance dredging may also provide a similar function. According to several MEP Reports in which inlet widening is identified as a potentially beneficial measure, increasing tidal flux is expected to decrease the nitrogen residence time within the embayment or salt marsh, thereby lowering the nutrient concentrations. With the return of natural salinities, nutrient balance, and improved tidal exchange, and with opportunities for sediment to move more naturally through a coastal system, native plant and animal species may return and thrive.

Key benefits of inlet widening include:
- Provides passive treatment with minimal O&M
- Has numerous ecosystem benefits
- Nitrogen removal rate is dependent on many factors, including scope of restoration up to full tidal exchange

Screening Criteria for Inlet Widening
Preliminary feedback from Water Quality Advisory Panel, as well as the depth differential between the ponds and Pleasant Bay indicates that inlet dredging would not increase tidal prism. **Inlet widening is prohibited in the terminal ponds because they are part of the Pleasant Bay Area of Critical Environmental Concern (ACEC).**

- Waterbodies identified in MEP Reports as potentially beneficial (**none in Orleans watersheds under consideration**)
- Waterbodies identified by local stakeholders as constricted, and where the increased tidal volume would lead to an enhanced tidal prism and thus nitrogen removal.

Key Permitting Authorities for Inlet Widening
- Conservation Commission
- MassDEP – TMDL-credit
- MassDOT
- Division of Marine and Fisheries (DMF)
- Coastal Zone Management
- Natural Heritage
- US EPA – TMDL-credit
- US Army Corp of Engineers

Pilot Projects on Cape Cod

The Town of Falmouth is currently in the design and permitting phase of an inlet widening demonstration project for Bournes Pond. This project involves widening the current inlet from 50' to 90', with a new road and bridge, and is expected to remove over 50% of the nitrogen load entering this coastal pond. The permitting and monitoring framework is currently being established, and could serve as a valuable blueprint for other inlet widening initiatives on Cape Cod.

COASTAL HABITAT RESTORATION

- Timeframe for water quality improvements (water clarity, nitrogen removal from water column) once implemented are within the first year of full growth.
- Coastal Habitat Restoration is a remediation technology.

Restoration of coastal habitats includes establishing and/or enhancing estuary salt marshes, eel grass beds, and enhancing historic shellfish beds or reefs together as an ecosystem. The installation of riparian buffer zones and floating islands are also tools for restoring coastal habitats. The focus of restoration in the context of the Technology Matrix is on creating or rehabilitating native shellfish habitats. The 208 Plan includes reef restoration as a key component of Coastal Habitat Restoration. Nitrogen-removal is based on shellfish uptake.

Under the Department of Fish and Game, the Division of Ecological Restoration (DER) has developed inventories of some potential wetland restoration sites throughout Massachusetts. The purpose of these inventories is to identify, evaluate, and prioritize restoration opportunities that can be advanced by DER and others. The Cape Cod Atlas of Tidally Restricted Salt Marshes describes 7 sites in Orleans, 2 of which are shared.

However, the use of Coastal Habitat Restoration as a tool for nitrogen-removal is a somewhat different paradigm that the DER program, as currently articulated.

Siting Criteria for Coastal Habitat Restoration

- Navigable waters (shoreline reef systems do not interfere in the same way as aquaculture)
- Freshwater stream inflow
- Adequate flushing
- River systems with shoreline available
- Areas where shoreline erosion is occurring
- Aquaculture not allowed by regulation, or acceptable due to aesthetics

Key Permitting Authorities for Coastal Habitat Restoration

- Conservation Commission
- MassDEP/US EPA – TMDL-compliance credit
- Division of Ecological Restoration (DER)
- Division of Marine and Fisheries
- MassDOT
- Natural Heritage
- US Army Corps of Engineers
- US Fish and Wildlife Service
- Coastal Zone Management
- Landowners
- Pleasant Bay Area of Critical Environmental Concern may create other permitting requirements.

Local departments that may also be involved:

- Department of Public Works

Limitations and Constraints

- Life cycle and monitoring costs
- Practical implementation (specific locations that lend themselves to habitat restoration, risk management)
- Actual nitrogen-removal rates for different growing systems
- Maintenance and management

Pilot Projects on Cape Cod

- None for nutrient remediation: any demonstration site should be a self-contained small estuary where benthic as well as water quality conditions can be easily characterized and monitored

Next Step:

- Review terminal ponds and estuaries where coastal habitat restoration might be feasible and desirable.
- Planning for this approach should include consideration of the spectrum of shellfish growing options including propagation, aquaculture and reef programs to determine the best approach for different waterbodies.

FLOATING CONSTRUCTED WETLANDS

- Timeframe for water quality improvements (water clarity, nitrogen removal from water column) once implemented are within the first year of full growth.
- Floating Constructed Wetlands are a remediation technology.

Manmade floating "islands" act as floating wetlands that treat waters within ponds and estuaries. The islands are made of recycled materials that float on ponds or estuaries, exposing the plant's roots to the pond and estuarine waters. The root zones provide habitat for fish and microorganisms while reducing nitrogen and phosphorus levels. The floating islands can also be designed to allow shellfish and seaweed to grow which can be harvested, offsetting some of the systems costs. Some systems circulate surface water through the island, exposing the water to the root zones of the plants. The islands can be installed with shellfish beds and/or salt marsh grasses potentially assisting with their establishment. The islands are generally stationary and can be installed with walkways to access and maintain the plants growing on the islands. The islands require little O&M and do not need to be removed during the winter months, even if freezing water is a concern.

Siting Criteria for Floating Constructed Wetlands

- Navigable waters (reef systems do not interfere in the same way as aquaculture)
- Freshwater stream inflow
- Adequate flushing
- River systems with shoreline available
- Areas where shoreline erosion is occurring
- Aquaculture not allowed by regulation, or acceptable due to aesthetics

Key Permitting Authorities for Floating Constructed Wetlands

- Conservation Commission
- MassDEP/US EPA – TMDL-compliance credit
- US Army Corps of Engineers
- Division of Marine and Fisheries

- Pleasant Bay Area of Critical Environmental Concern may create other permitting requirements.

Local departments that may also be involved:
- Department of Public Works
- Harbormaster/Shellfish Dept.

Limitations and Constraints
- Life cycle and monitoring costs
- Practical implementation (specific locations, risk management)
- Conflicting uses of water (boating, navigation)
- Actual nitrogen-removal rates for different growing configurations
- Maintenance and management

Pilot Projects on Cape Cod
- Martha's Vineyard demonstration project, collaboration between Floating Islands International and Martha's Vineyard Shellfish Group, was installed mid- summer of 2014. Monitoring began, and will continue through (at minimum) summer, 2015. Four sites, with 2 – 4 wetlands systems per site are being evaluated.

The following research questions are being assessed:
- Will the BioHaven® matrix bio□foul from natural marine aquatic organisms or suspended detritus to a point where the matrix will not provide positive benefits in these marine environments at this scale?
- Does the matrix have any application for Geukensia demissa spat collection and/or culture?
- Does the periphyton that becomes attached to the matrix exhibit nitrification and/or denitrification potential? If so, to what extent?

LAND USE CONTROLS

- Timeframe for water quality improvements (water clarity, nitrogen removal from water column) once implemented depend on growth timeframes and groundwater travel times.
- Land Use Controls are a source reduction technology.

Land use planning is often implemented through zoning changes. Compact and open space development, transfer of development rights and overlay districts are three of several possible land use planning tools that are highlighted in the Technology Matrix. Purchase of land for open space and conservation restrictions also reduce future growth. Currently, Orleans has an average of ¾ acre zoning throughout town, with 6 units/acre maximum for apartments in certain areas.

Orleans Buildout Analysis - Summary of Findings
Existing level of development

Single family homes	3617
Condominium units	642
2-family home units	88
3-family home units	18
Other multi unit dwellings	104
Housing Authority	115
Apts. in Industrial District	22
Apts. in Business dists.	
Permitted accessory apartments	3
Total existing dwelling units	4,609

Potential Future Development

Vacant developable (undividable) building lots	528
Potential new lots in Res. Districts	274
Potential new apts in business districts	412
Potential new apts. in Industrial District	98
Potential new apts. in the Village Center	290
Total Potential Development	1,768

Current Density: 2.05 residents per dwelling unit (US Census)

Siting Criteria for Land Use Changes

- Detailed build-out analysis based on "net useable land" has been completed by the Orleans Planning Department.
- Town Planner has confirmed that the findings are still valid.
- Findings incorporated into Comprehensive Wastewater Management Plan as "Practical Buildout"
- Land Use Controls should be pursued in the context of the Town's Local Comprehensive Plan

Key Approvals for Land Use Controls

- Planning Board
- Board of Selectmen
- Town Meeting

Local departments that will likely be involved:

- Planning Department

Limitations and constraints:

- Does not address current load
- Cannot stop all future load
- Public acceptance

SUMMARY OF 208 PLAN SCREENING LAYERS
Constructed Wetlands for Phyto-Technology
See 208 Screening Layers Map for exact locations

Locations include: Hopkins Island, parcel off White Pines Drive (wetlands), parcel off Route 6A at Boland Pond, and parcel off Indian Fort Hill Rd.

SUMMARY OF 208 PLAN SCREENING LAYERS
Constructed Wetlands for Groundwater Treatment
See 208 Screening Layers Map for exact locations

Rock Harbor:

- Constructed Wetlands for groundwater treatment - enhancement of existing wetlands system in two areas along creek
- Two parcels (wetlands) near Cedar Pond

Nauset Marsh – Town Cove:

- Constructed Wetlands for groundwater treatment – enhancement of existing wetlands at island E of Nauset Beach

Little Pleasant Bay:

- Constructed Wetlands for groundwater treatment – enhancement of existing wetlands east of Archer Lane, west of Sparrowhawk Rd along Bay, at Barley Neck (point) , Tar Kiln Road, Simpson Meadow island

Namskaket

- Constructed Wetlands for groundwater treatment - enhancement of existing wetlands system on several parcels

SUMMARY OF 208 PLAN SCREENING LAYERS
Constructed Wetlands for Wastewater Treatment
See 208 Screening Layers Map for exact locations

Rock Harbor:

- Constructed Wetlands for wastewater at Defiance Lane

Nauset Marsh – Town Cove:

- Constructed Wetlands for wastewater - several sites, to be reviewed as part of wastewater discharge planning

Little Pleasant Bay:

- Constructed Wetlands - several sites, to be reviewed as part of wastewater discharge planning

Namskaket

- Constructed Wetlands for wastewater at Boas Drive, off Salty Ridge Rod

Appendix C

Siting Evaluation Matrix

Town of Orleans, Massachusetts
Water Quality and Wastewater Planning
Aquaculture Demonstration Siting Evaluation

Criteria	Site A: Town Cove: Quahog Propagation		Site B: Mill Pond: Quahog Propagation		Site C: Little Pleasant Bay: Existing Grants		Site D: Pochet: Oyster Reef		Site E: Arey's Pond: Oyster Singles in Floating		Site F: Lower River: Oyster Singles in Floating		Site G: Quanset: Oyster Reef	
	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Site Suitability														
Available Growing Area/Adequacy of Acreage	1	1	1	1	1	1	1	1	0	0	1	1	1	1
Water Quality Indicators	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Disease/Predation	-1	-1	-1	-1	0	0	0	0	0	0	0	0	1	1
Ease of Access:	0	0	0	0	0	0	0	0	1	1	1	1	1	1
Aesthetic Impacts	1	1	1	1	1	1	1	1	-1	-1	-1	-1	1	1
Representativeness of the Site (Transferability)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Use Conflicts	1	1	1	1	1	1	1	1	0	0	-1	-1	1	1
Ability to Co-Locate with other Non-Traditional Technologies	1	1	1	1	1	1	1	1	1	1	1	1	1	1
												-		-
Permitting														
Abutter Comaptability	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Wild Harvest Conflicts (DMF)	1	1	1	1	1	1	0	0	1	1	0	0	0	0
Grow-Out to harvest size Allowed (DMF)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Permittability	1	1	1	1	1	1	0	0	1	1	1	1	1	1
												-		-
Project Evaluation														
Expected Survival	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Overall Likelihood of Monitoring Plan to Yield Quantified Results	-1	-1	-1	-1	1	1	1	1	1	1	0	0	0	0
												-		-
Other/Overriding Considerations														
Town Cove/Mill Pond: drills preclude oysters (per Mass Shellfish Growers Assn (communication with Shellfish Constable)		-	-	-	-	-	-	-	-	-	-	-	-	-
Town Cove: population study of quahogs needed prior to additional shellfish propagation/demo (communication with Shellfish Constable)		-		-	-	-	-	-	-	-	-	-	-	-
Pochet: monitoring difficult if LPB is also a demo	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LPB: Shellfish Constable and Harbormaster recommended working with existing growers for demonstration														
Total Criteria Points	9		9		12		10		9		7		12	
Rank	4		4		1		3		4		7		1	

Notes:
- High Criteria Weight = Greater Importance
- Higher Rating = Better Conditions
- A good ranking (1) was assigned if the criterion could be fully met.
- A neutral ranking (0) was assigned if the criterion could be met in part, but not fully.
- A poor ranking (-1) was assigned if the criterion could not

Remarks

Arey's, Lower River and parts of Town Cove, much of the bottom is anoxic, fine-grained sediment (muck). This precludes bottom planting of oysters
Arey's has narrow Namequoit neck allowing better quantification of input water nitrogen concetrations, which increases likelihood that monitoring plan will quantify N
Pochet permitting may involve National Seashore, and access involves permission from private landowner
Pochet only measurable from a monitoring perspective if LPB aquaculture is not a demonstration
Pochet: Shellfish Contable thought this location was suitable for a "no take" zone/oyster reef
LPB has number of oysters being grown and harvested from required annual Shellfish Grant reporting
Town Cove/Mill Pond should have a quahog population study completed to establish baseline numbers before further quahog propagation/demonstration
Town Cove/Mill Pond have significant drill population; planting of oysters is not recommended per Massachusetts Shellfish Officers Association Best Management Practice
The Lower River is an open cove, causal water quality improvements are hard to quantify by monitoring
The Lower River has visibilty, good for public education

ATTACHMENT J

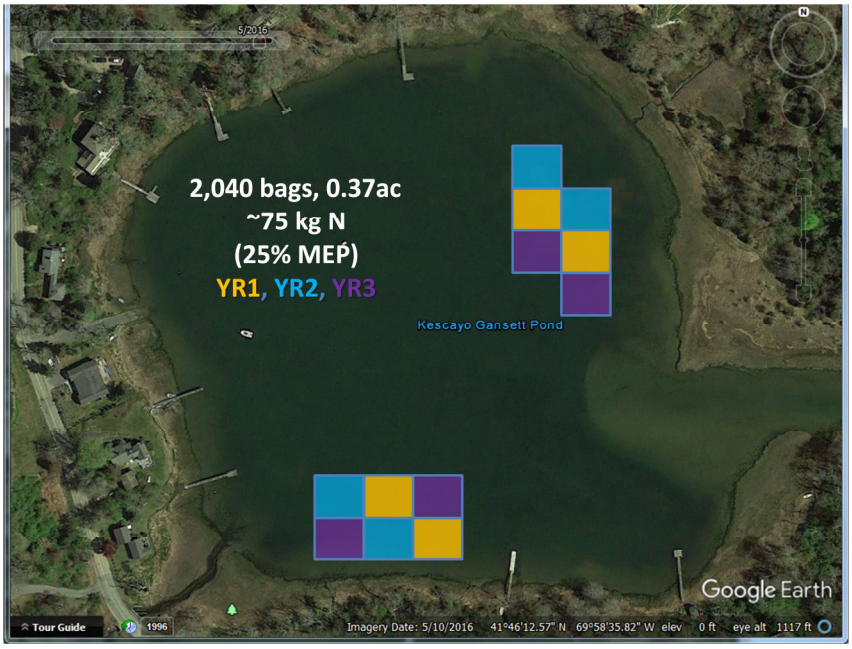
LONNIE'S POND AQUACULTURE MANAGEMENT PLAN

Lonnie's Pond Aquaculture and Nitrogen Management Plan

FINAL

October 2018

Town of Orleans



Prepared by:

Coastal Systems Group
School for Marine Science and Technology
University of Massachusetts Dartmouth
706 South Rodney French Blvd.
New Bedford, MA 02744-1221

Lonnie's Pond Aquaculture and Nitrogen Management Plan

FINAL
October 2018

Prepared for

Town of Orleans

Prepared By

Brian Howes, Director CSP/SMAST
Ed Eichner, Senior Water Scientist/Project Manager

COASTAL SYSTEMS GROUP
SCHOOL FOR MARINE SCIENCE AND TECHNOLOGY
UNIVERSITY OF MASSACHUSETTS DARTMOUTH
706 South Rodney French Blvd., New Bedford, MA 02744-1221

With the assistance of:

Town of Orleans
Nathan Sears and George Meservey
Shellfish and Waterways Improvement Advisory Committee

Science Wares, Inc.
Eric Karplus

Lonnie's Pond Aquaculture and Nitrogen Management Plan

FINAL

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Appendix A. AECOM Lonnie's Pond Aquaculture Management Plan. Final. January 2018

Appendix B. Coastal Systems Program, School of Marine Science and Technology (CSP/SMAST), University of Massachusetts-Dartmouth, Lonnie's Pond Shellfish Demonstration Project: Year 2 Monitoring Summer/Fall 2017 Oyster Deployment. September 2018

I. Introduction

The Town of Orleans is working on options to reduce nitrogen loads to its estuaries through a variety of strategies, including improved wastewater treatment, but also through lower-cost, non-traditional approaches. These efforts reflect an understanding of the community and economic links to healthy ecosystems and clean water, but also strive to attain reductions required by the Massachusetts Department of Environmental Protection (MassDEP) through their adoption of Total Maximum Daily Loads (TMDLs) for impaired waters under the federal Clean Waters Act.

In 2007, MassDEP finalized TMDLs for Pleasant Bay that identified portions of the estuary, including Lonnie's Pond, as having excessive nitrogen.[1] The Massachusetts Estuaries Project report for Pleasant Bay[2], which is the technical basis for the TMDLs, suggested that 300 kg/yr of nitrogen would need to be removed from Lonnie's Pond to mitigate the impairments.

In 2016, the Town began a non-traditional oyster aquaculture demonstration project in Lonnie's Pond as part of examining innovative non-sewering approaches to nitrogen management. The aquaculture project was planned as a three-year effort to evaluate the water quality impacts and implementation issues associated with enhanced aquaculture for nitrogen reduction and potential achievement of the TMDL without sewering within the Pond watershed.

Monitoring during the Lonnie's Pond Demonstration Project has found significant removal of nitrogen due to shellfish growth and bio-deposition and some water quality improvements. However, as the amount of nitrogen removal by oyster aquaculture is becoming clear, focus has shifted to the logistical, regulatory, monitoring, and public coordination components that are needed for its long-term use in the Town's nitrogen management program for its estuaries.

This Lonnie's Pond Aquaculture and Nitrogen Management Plan provides a detailed framework for the long-term use of oyster aquaculture in this basin. Its goal is ensuring the reliability of regular oyster aquaculture for nitrogen removal. The overall concept of the plan is that the Town will partner with private contractors to oversee and implement the Plan. An Aquaculture Contractor will be responsible for purchasing, installing, maintaining, and removing oysters deployed in floating bags started as seed and then grown from spring to removal in early winter. A separate, Monitoring Contractor will coordinate with the Aquaculture Contractor to complete nitrogen monitoring of both the shellfish and water quality. The Monitoring Contractor will also work with the Town Natural Resource Manager (or designee) to provide an annual aquaculture report detailing the number and amount of shellfish grown, the amount of nitrogen removed and resulting water quality relative to compliance with the TMDL. This Plan will be coordinated initially through the Shellfish and Waterways Improvement Advisory Committee to ensure that start-up information is publicly shared and available. After initial start-up, the Town Natural Resource Manager (or designee) will be ensure regular public sharing of project performance.

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[1] MassDEP. 2007. FINAL Pleasant Bay System Total Maximum Daily Loads For Total Nitrogen (Report # 96-TMDL-12, Control #244.0). 53 pp.

[2] Howes B., S. W. Kelley, J. S. Ramsey, R. Samimy, D. Schlezinger, E. Eichner (2006). Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Pleasant Bay, Chatham, Massachusetts. Massachusetts Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA.

The Plan includes shellfish and water quality management decision points and their likely schedule within each year, a communications plan to ensure that all Town decision makers and citizens understand the in-pond activities, results, and responsibilities for costs and associated contingencies, such as dealing with catastrophic loss/death of oysters. This Plan also includes details such as the ideal number of oysters, their sizes, their deployment areas, and their ultimate use/sale.

II. Lonnie's Pond Aquaculture Deployment

To initiate the Aquaculture portion of the Lonnie's Pond Aquaculture and Nitrogen Management Plan, an Aquaculture Contractor will be selected by the Town through a public procurement process in November for a 3 year renewable contract. The Aquaculture Contractor will be responsible for purchasing, installing, maintaining, transporting, and harvesting the shellfish. The Aquaculture Contractor will be provided access to the available aquaculture gear previously developed and used during the demonstration project, including 680 floating spat bags and 2,040 6 mm diamond mesh floating bags. A floating bag setup similar to that used in the Demonstration Project is to be used, although the oyster density may be varied based on growth results.

II.A. Aquaculture Contractor: Selection, Responsibilities

II.A.1. Aquaculture Contractor: Selection

The selection of an Aquaculture Contractor for Lonnie's Pond will be completed through a public procurement process, including the development of a Request for Proposals (RFP). The Town will publicly advertise a RFP in November of each year a new contractor is needed and select the Aquaculture Contractor by December 1. A pre-bid conference will be held by the Town to allow inspection of the gear previously developed and used during the demonstration project; details for the pre-bid conference will be included in the RFP. The RFP will follow standard Town procurement requirements and include the following criteria for review:

1) Experience in oyster aquaculture, both on Cape Cod and within Orleans.
2) Experience deploying more than 2 million oyster seed prior to June 1.
3) Certification of access to approved upweller space and experience in growing seed in an upweller or ability to provide the required amount of oyster seed.
4) Experience with use and maintenance of existing Town gear or equivalent.
5) Description of planned oyster deployment, including specific shellfish deployment areas, shellfish care between installation and harvesting, maintenance, and any additional equipment that will be deployed (see II.B for details of deployment); alternative strategies for oyster counts and management to attain the required N removal will be considered,
6) Description of planned use of public facilities, such as the boat ramp, including anticipated time of day and frequency of access
7) Description of how the Contractor will minimize visual, noise and traffic relative to abutters
8) Documentation of liability insurance
9) Presentation of any necessary regulatory documents

II.A.2. Aquaculture Contractor: Contractor Responsibilities

The Aquaculture Contractor will be responsible for purchasing, transporting, installing, maintaining and removing the shellfish. Associated details of Aquaculture Contractor responsibilities include:

1) Creation of 23,400 kg of net weight of oysters by the time the oysters are removed (based on Demonstration Project results, this should remove 75 kg of total nitrogen). This growth will be achieved by selecting either of the following scenarios:

   Scenario A:

   - acquisition and deployment of a minimum of 5.5 million Year 1 seed oysters (2 to 3 mm) by June 1 in floating spat bags;
   - then selecting and transferring the best growing oysters to 2,040 6 mm mesh bags, such that there will be 1,000 oysters per bag;
   - then allowing these oysters to grow and removing them between November 15 and December 15

   OR

   Scenario B:

   - acquisition and deployment of a minimum of 2.1 million Year 1 seed oysters (10 to 25 mm) by July 1 in 2,040 6 mm mesh bags, such that there will be 1,000 oysters per bag;
   - then allowing these oysters to grow and removing them between November 15 and December 15

   If monitoring results show that this amount of oysters needs to be reduced or increased in subsequent years, it will be addressed in annual modifications and/or a future contract.
2) providing documentation to the Town by December 31 that adequate supply of Year 1 seed oysters has been ordered and planned delivery is prior to June 1. The Aquaculture Contractor will ensure that oysters are certified disease-free and obtained from a certified facility.
3) providing (or fabricating) any additional gear necessary for oyster installation and necessary trucks or alternatives for transport of shellfish. All bags shall be black to minimize visual aesthetics, anchoring of gear shall use of telescoping auger system (helix anchors) or equivalent, and other gear equivalent to the current Demonstration Project will be required. Note that if screw anchors (augers) are used to anchor the deployment, no Army Corps of Engineers permit is needed, but the Contractor should confirm with Massachusetts Division of Marine Fisheries (MassDMF).
4) boats and other equipment for installation, movement, maintenance, and collection of the bags and racks,
5) an acceptable plan for restoring shellfish if oysters die or are lost before August 1 in any given year, including the time needed for re-deployment. The Aquaculture Contractor should identify potential mid-season suppliers of Year 1 oysters as part of the replacement plan. If shellfish are lost the Aquaculture Contractor must submit a brief memorandum documenting the reason for the loss, the timing of loss and reinstallation (including costs to contractor) and how it will be avoided in the future,
6) installation and removal of gear in spring and fall with gear removed by 2 weeks after harvest each year, but no later than December 15, except with permission of the Natural Resource Manager (or designee),

7) ensuring that oysters are certified disease-free prior to their removal from Lonnie's Pond and obtaining permission from MassDMF and the Natural Resource Manager (or designee) to move the oysters to a new site.
8) storage of all gear used and emergency backup gear over the course of the contract,
9) notifying the Town of any survival or growth concerns, including signs of disease,
10) coordinating any water quality or shellfish sampling with Monitoring Contractor,
11) providing all necessary information to the Monitoring Contractor for the completion of the Lonnie's Pond Aquaculture/TMDL Annual Report,
12) coordinating response to any catastrophic events (*e.g.*, significant shellfish die-off, significant gear destruction) with Town and Monitoring Contractor, and
13) providing a plan for the oyster sale or the transfer to other sites independent of town funding or liability.
14) obtaining a renewable annual permit from MassDMF for the oyster deployment.
15) providing a commitment to work to address abutters concerns as much as possible, including visual impacts, minimizing noise, restricting work hours, and minimizing vehicle parking at the boat ramp.

II.A.3. Aquaculture Contractor: Town Responsibilities

II.A.3.a. Regulatory Approvals

Following the selection of the Aquaculture Contractor, the Town will work with the Aquaculture Contractor to secure: 1) a Board of Selectmen license from the Town, 2) a Division of Marine Fisheries certification of the Town license, 3) a Notice of Intent (NOI) or Request for Determination of Applicability (RDA) from the Town Conservation Commission. These permitting steps will be completed prior to Spring deployment. The Town will also ensure that the Aquaculture Contractor has obtained a renewable annual permit from MassDMF for the oyster deployment. If any other regulatory approvals are required, the Town will work with the Aquaculture Contractor to obtain necessary approvals.

II.B. Shellfish: Deployment Details

II.B.1. Shellfish: Type, Quantity

Shellfish will be deployed with the purpose of removing a Net Live Biomass (shell + tissue) of 23,400 kg (removal weight minus deployment weight) to yield a Net Nitrogen Removal of 75 kg N per year following one of the two acceptable scenarios below:

Scenario A:

- acquisition and deployment of a minimum of 5.5 million Year 1 seed oysters (2 to 3 mm) by June 1 in floating spat bags;
- then between July 1 and July 20, transferring seed to 2,040 6 mm mesh bags, such that there will be 1,000 oysters per bag;
- then allowing these oysters to grow and removing them between November 15 and December 15.

OR

Scenario B:

- acquisition and deployment of a minimum of 2.1 million Year 1 seed oysters (10 to 25 mm) by July 1 in 2,040 6 mm mesh bags, such that there will be 1,000 oysters per bag;
- then allowing these oysters to grow and removing them between November 15 and December 15.

If monitoring results show that this amount of oysters needs to be reduced or increased in subsequent years, it will be addressed in annual modifications and/or a future contract. The target population will be sustained with documentation of any replacements until at least November 15. All oysters and accompanying gear must be removed from Lonnie's Pond no later than December 15 with certification that the shellfish are disease-free prior to their removal from Lonnie's Pond and with permission from MassDMF and Natural Resource Manager to move the Year 1 oysters to a new site. The Aquaculture Contractor shall complete both the initial shellfish deployment and end of season removal within seven days.

II.B.2. Shellfish: Deployment Locations

The maximum extent of the deployment locations will be approximately 0.37 acres, similar to the area used during the Demonstration Project in 2017 and 2018 (Figure 1**)**. It is anticipated that a rotational deployment strategy will be implemented where the same site is not used for more than two consecutive years. Locations will be finalized with the Town Natural Resource Manager (or designee) assisted by the Monitoring Coordinator who will provide GPS coordinates, before submission for Conservation Commission review.

II.B.3. Shellfish: Density and Care

Based on estimates developed through the Demonstration Project, after the shellfish reach the size where they can be deployed in the 6 mm mesh bags, the density will be approximately 1,000 oysters per bag from July to removal. Installation will be similar to the Demonstration Project setup with 800 floating bags along lines approximately 10 ft apart within each of the 80 ft X 120 ft areas (as shown in Figure 1). As the oysters grow, it is anticipated that actual growth conditions may require adjustments by the Contractor. The final number of bags is anticipated to be approximately 2,040 bags based on information developed during the Demonstration Project (see Appendix A). The number of spat bags in Scenario A is flexible, but must fit in the deployment footprint.

Bags will be flipped on a weekly basis at the beginning of the growing season and bi-weekly later in the season; this practice was deemed to be sufficient to prevent tunicate (sea-squirt) and algal growth and help extract feces and pseudofeces. Dead oysters should be removed, at a minimum, when bags are split. Gear will be inspected and repaired if necessary during these visits. Aquaculture activities on the pond shall be performed between the hours of 7 AM and 6 PM Monday through Friday, except in preparation for storms.

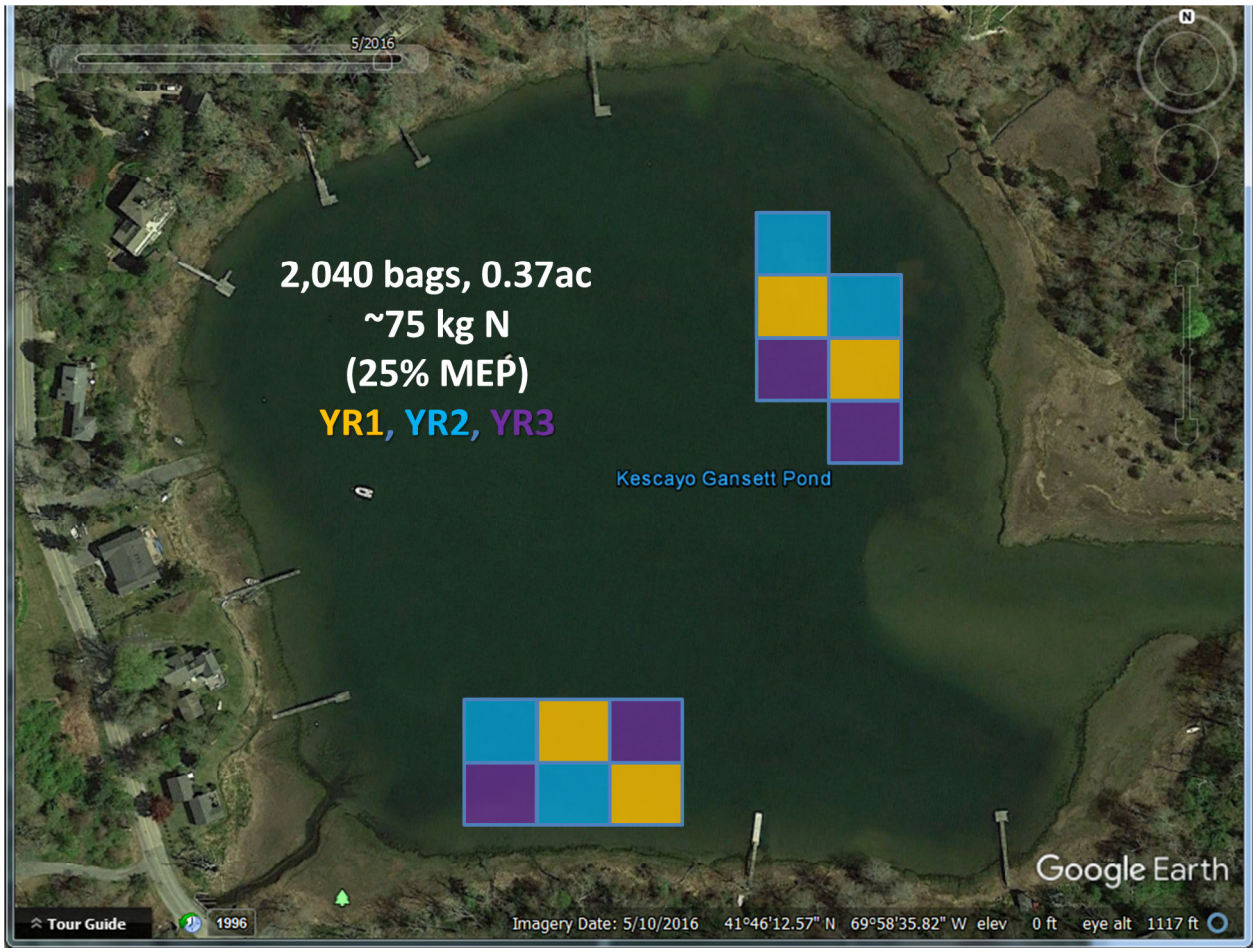


Figure 1. Lonnie's Pond Oyster Aquaculture Deployment Area. During Year 1, the deployment will be within the four boxes shaded yellow shown above, which have an area of 0.37 acres (or 2% of the pond area). This area is the same surface coverage as utilized during the Demonstration Project. During Years 2 and 3, the deployment area will remain 0.37 acres, but will shift to other boxes within the overall deployment area as shown. Rotation of deployment areas will occur to encourage additional nitrogen reductions and will try to avoid use of the same areas for more than two consecutive years. Deployment areas will be adjusted and reviewed annually based on the oyster count needed to attain N removal.

II.B.4. Shellfish: Catastrophic Loss (Death) or Equipment Loss

The timing of replacement noted herein is based on the maximum deployment being spring (no later than June 1 in Scenario A and July 20 in Scenario B) to December 15 each year, with no overwintering of oysters in Lonnie's Pond. Once oysters are removed from Lonnie's Pond by the Aquaculture Contractor, they are solely the responsibility of the Aquaculture Contractor.

In the event of a catastrophic loss of the shellfish population (defined as more than 50% of the initial annual population), the Aquaculture Contractor shall strive to replace the population as soon as replacements are available if the loss occurs in April, May, June, or July. If the loss

occurs in August, September, October, November, or December, the Aquaculture Contractor will not be required to replace the population.

In the event of a significant gear loss due to a storm or theft during April, May, June, or July, the Aquaculture Contractor will be responsible to replace the gear at their cost and strive to install the replacement gear within the same month. If significant gear loss due to a storm or theft occurs during August, September, October, November, or December, the Aquaculture Contractor will be responsible to replace the gear at their cost, but re-installation of the replacement gear will not be required until normal spring deployment the following year.

III. Lonnie's Pond Nitrogen and Ecosystem Monitoring

Monitoring in Lonnie's Pond will be completed in order to provide the Town with TMDL compliance documentation. Monitoring will include sampling of water quality, shellfish nitrogen content, and sediment N content. Monitoring will occur at different frequencies depending on the source being sampled. It is anticipated that the Town will select a Monitoring Contractor to complete the ecosystem monitoring tasks.

III.A. Monitoring Contractor: Selection, Responsibilities

III.A.1. Monitoring Contractor: Selection

The selection of a Monitoring Contractor for Lonnie's Pond will be completed through a public procurement process, including the development of a Request for Proposals (RFP). The Town will publicly advertise a RFP in January prior to the first year of deployment for a 3 year duration (same as Aquaculture Contractor, also renewable) and select the Monitoring Contractor by February 15. The RFP will follow standard Town procurement requirements and include the following criteria for review:

1) Experience in water quality sampling, both on Cape Cod and within Orleans
2) Experience with types of sampling required for Lonnie's Pond, including potentially use and coordination of volunteers, shellfish sampling, and sediment sampling
3) Description of planned sampling strategy, including anticipated laboratories for assays, detection limits, and how procedures may differ from those used during the Demonstration Project and the MEP.
4) Documentation of applicable insurance
5) The Monitoring Contract must also demonstrate acceptability of data produced for regulatory agencies (*i.e.*, compliance)

III.A.2. Monitoring Contractor: Contractor Responsibilities

The Monitoring Contractor will be responsible for collecting, handling, and transporting all samples to matrix-specific laboratories within timeframes required by assay methods (see Sections III.B and III.C). The Monitoring Contractor will select the laboratories and ensure that assay methods and detection limits are comparable or superior to those used during the Demonstration Project. The Monitoring Contractor will submit a Lonnie's Pond Nitrogen Management QAPP to the Town and, following Town review, to MassDEP for approval to ensure MassDEP acceptability of results for TMDL compliance. The Monitoring Contractor will also be responsible for preparing both a Semi-Annual Technical Memorandum and a Lonnie's Pond Aquaculture/TMDL Annual Report with the assistance of the Aquaculture Contractor (see Section IV). Each of these reporting documents will be submitted to the Town for review and final approval before being submitted to MassDEP. Monitoring activities on the pond shall be

performed between the hours of 6 AM and 6 PM Monday through Friday, except in preparation for storms.

III.B. Water Quality Sampling

Water quality sampling will include both grab samples and continuous monitoring and will focus on summer months, which are the primary focus for TMDL compliance. Sampling methods and chemical assays will generally be the same as previous MEP and Town samplings and comparability to historic data is required.

III.B.1. Water Quality Grab Sampling

Water quality grab sampling will be conducted every two weeks between June 15 and September 15 in each of the three years. A reduction in sampling to only once a month may be allowed in future years if system variability within the monitoring results becomes sufficient documented and less frequent sampling is deemed sufficient for compliance by MassDEP. The Monitoring Contractor will participate in any discussion about sampling with the Town and MassDEP. Water quality samples will be collected during the morning (6 AM to 9 AM) on the outgoing (ebb) tide. Sampling dates will be selected so that sampling occurs at approximately mid-ebb tide (1 hr before to 1 hr after). Since these are the same procedures utilized in the Demonstration Project and the volunteer sampling coordinated through the Marine and Fresh Water Quality Committee, it is envisioned that volunteers will continue to collect this portion of the Lonnie's Pond sampling.

Samples will be collected at two depths:

- one sample at 0.25 meters below the surface (the "surface" sample).
- one sample from 0.5 meters above the bottom (the "bottom" sample)

Field measurements for total depth, temperature, dissolved oxygen, and clarity/Secchi will also be recorded at the same location (Figure 2). All sampling methods and sample handling will follow previously approved Town and MEP QAPP procedures and the project-specific Lonnie's Pond Nitrogen Management QAPP.

Collected grab samples will be assayed for the following parameters: nitrate+nitrite, ammonium, total dissolved nitrogen, particulate nitrogen, ortho-phosphorus, chlorophyll a, pheophytin a, and particulate carbon. All assay methods will follow those described in previously approved Town and MEP QAPP procedures and the project-specific Lonnie's Pond Nitrogen Management QAPP.

III.B.2. Water Quality Continuous Monitoring

Two continuous monitoring devices will be installed at two depths (0.5 m and 3.5 m). Both devices will have the following probes: dissolved oxygen, depth, salinity, temperature, and chlorophyll-a. The devices will be installed in late May/early June and removed in September to coincide with the critical compliance period. The device will be programmed to record readings every 15 minutes.

III.B.3. Contingency Monitoring

Funding will be reserved to address "emergency" monitoring associated with extreme events that are anticipated to occur rarely during the growing season, including harmful algal blooms, signs of shellfish disease, and hurricanes.

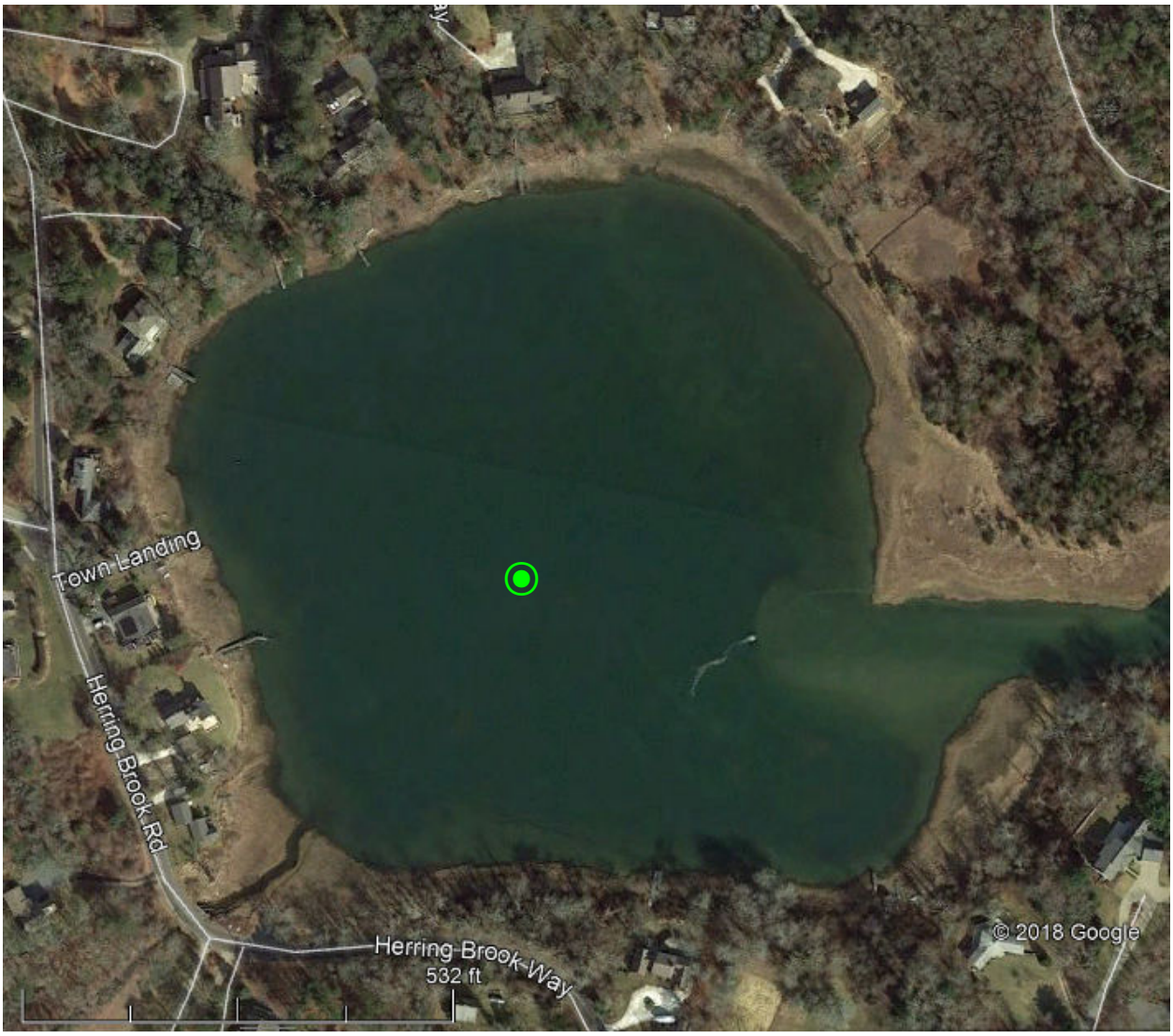


Figure 2. Water Quality Monitoring Sampling Location. Location indicated with green bullseye.

III.C. Shellfish Sampling

Shellfish sampling will be conducted by the Monitoring Contractor to measure the amount of nitrogen retained and removed through removal of oysters at the end of each growing season. This sampling will be coordinated with the Aquaculture Contractor. The amount of nitrogen removed will be part of the TMDL compliance reporting, as will the size and number of oysters harvested.

At the beginning of the growing season, the Aquaculture Contractor will coordinate with the Monitoring Contractor to measure the total weight and estimate the total population of oysters deployed in Lonnie's Pond. At the end of the growing season, the Aquaculture Contractor will coordinate with the Monitoring Contractor to weigh all the oysters as they are removed from Lonnie's Pond.

A representative sample of one hundred (100) shellfish will be collected, weighed, and analyzed for nitrogen twice during the shellfish season in batches of no more than 10 oysters, once at the beginning of the growing season prior to deployment and once at the end of the growing season. If seed are being assayed, screening for size can be used, and groups of seed can be weighed and analyzed as long as at least 5 groups are assayed. Analysis will be completed on whole shellfish. End of season oysters will be measured individually. Comparison of the nitrogen content in the pre- and post-growing season samples combined with the weight and post-growing count will determine the amount of nitrogen removed by shellfish in Lonnie's Pond. All nitrogen content assay methods and sampling procedures will follow those described in the Demonstration Project (see Appendices A and B).

III.D. Sediment Sampling

Sediment sampling will be conducted to measure the forms and amount of nitrogen deposited to the sediments by the shellfish during a given growing season. The amount removed will be part of the TMDL compliance reporting.

Eight (8) cores will be collected and incubated twice to determine the amount and forms of nitrogen under a selected portion of the shellfish area. Cores will be collected in August and early October to determine N_2 release as an additional removal of nitrogen associated with the aquaculture deployment. Four (4) cores under the floating bags and 4 cores at a "control" area adjacent (>15 m outside) the floating bags will be collected during each core collection run. Core collections will follow procedures used during the demonstration project (Appendix B). Core data will be reviewed each year to assess the need for additional sampling in the following year (agreement between the Town, Monitoring Contractor and MassDEP). Water column sampling at each meter will also be conducted at the time of core collection to determine the water column nitrogen forms. Comparison of the forms of nitrogen in the pre- and post-growing season samples and in the various redox conditions of the cores will be considered with the water quality data to estimate the amount of nitrogen that has been removed via denitrification. All nitrogen content assay methods will follow those described in the Demonstration Project (see Appendix B).

IV. Lonnie's Pond Reporting and Communication

The Lonnie's Pond Aquaculture Management Project will include two primary communication pathways: a) reporting to state agencies and b) reporting to Orleans decisionmakers, citizens, and staff. Two documents will be prepared by the Monitoring Contractor with cooperation from the Aquaculture Contractor and analytical facilities and will be the main focal points for providing updates on Project status: 1) Lonnie's Pond Aquaculture/TMDL Annual Report and 2) Lonnie's Pond Aquaculture/TMDL Semi-Annual Status Update Technical Memorandum. However, these formal reports do not take the place of on-going communication between the Aquaculture Contractor, Monitoring Contractor, the Natural Resource Manager (or designee) and the Shellfish and Waterways Improvement Advisory Committee.

IV.A. Lonnie's Pond Reports: Annual Report and Semi-Annual Status Update

The Lonnie's Pond Aquaculture/TMDL Annual Report will, at a minimum, include summaries of the following:

1) Aquaculture summary, including shellfish counts, size, and weight at initial deployment and at removal, and notes on maintenance and care,
2) Shellfish nitrogen mass removal based on comparison of average weight and nitrogen content at the time of delivery and upon removal at the end of the growing season,
3) Progress toward meeting TMDL and MassDEP surface water standards based on water quality results (both continuous records and grab samples), shellfish nitrogen removal, and sediment core results, and
4) Recommendations for refinements in any Project procedures and likely changes in costs for refinements.

The Lonnie's Pond Aquaculture/TMDL Semi-Annual Status Update will be a technical memorandum prepared by the Monitoring Contractor by the end of the July and will summarize initial insights from shellfish deployment and ecosystem monitoring (including dates of installation, maintenance, and monitoring), but will not significantly review any monitoring data. The Semi-Annual Status Update will incorporate information and data collected by the Aquaculture Contractor. The Update will be submitted to Natural Resource Manager (or designee) and the Shellfish and Waterways Improvement Advisory Committee and presented by the Monitoring Contractor at a Committee meeting.

IV.B. Lonnie's Pond Reports: Delivery Dates and Public Presentations/Outreach

The Lonnie's Pond Aquaculture/TMDL Annual Report will be prepared by the Monitoring Contractor with cooperation from the Aquaculture Contractor and analytical facilities. The Annual Report will be publicly presented in draft form at a forum acceptable to both the Town and the Monitoring Contractor in December and a final form will be delivered to the Town in January following the receipt of any comments. The Lonnie's Pond Aquaculture/TMDL Semi-Annual Status Update Technical Memorandum will be delivered to the Town in July and will be publicly presented at a forum acceptable to both the Town and the Monitoring Contractor. The Town will mail agendas and any meeting materials to Lonnie's Pond abutters and other concerned citizens prior to the presentations on both the Semi-Annual Status Update and the Annual Report. Both the Technical Memorandum and the Annual Report will be available on the Town website, as will any presentation materials.

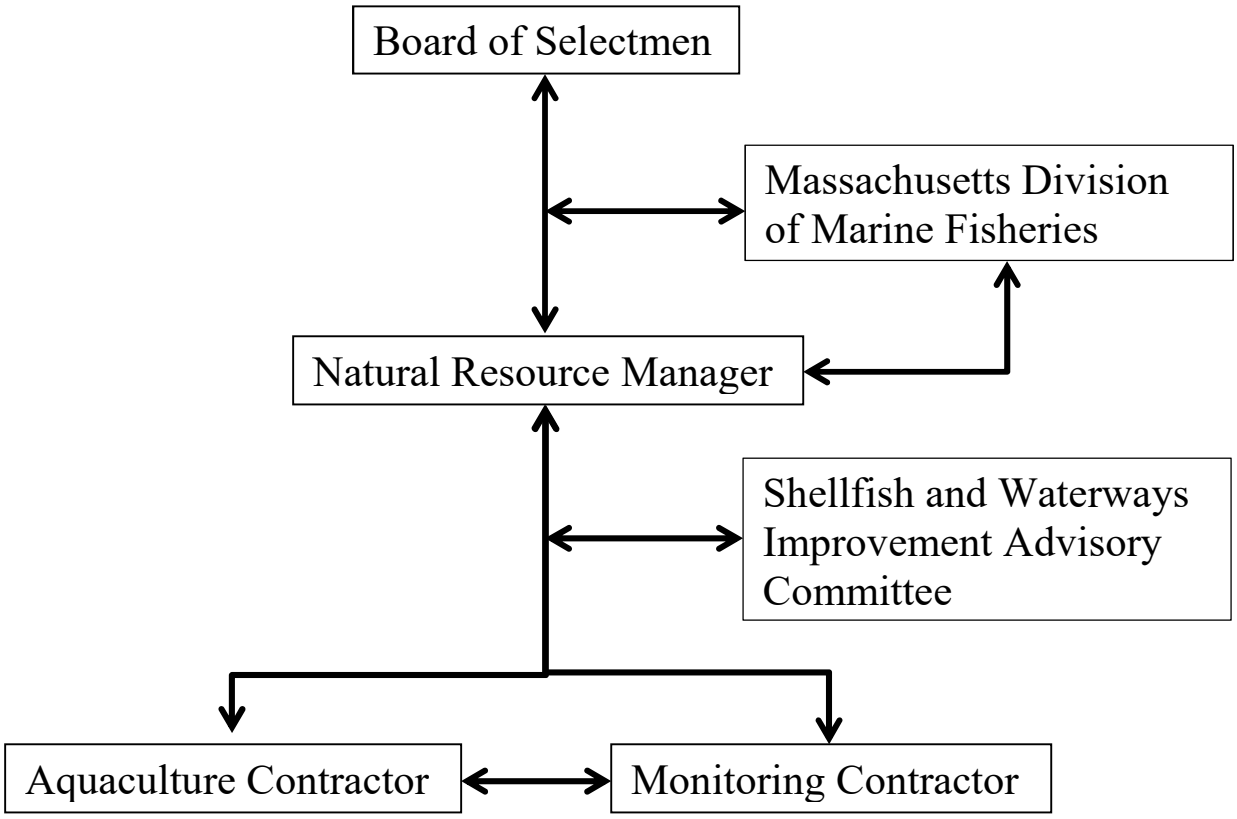
IV.C. Lonnie's Pond Reports: Regulatory Reporting

The Town, with support from the Monitoring Contractor, will submit the Lonnie's Pond Aquaculture/TMDL Annual Report to MassDEP in support of TMDL and Surface Water Quality Standards compliance. A copy of the Annual Report will also be submitted to MassDMF and the Town.

V. Lonnie's Pond Aquaculture and Nitrogen Management Plan Schedule

Action	Date	Frequency
Town Actions		
Town publicly advertises Aquaculture Contractor RFP	November	YR1 and as needed
Town holds Aquaculture Contractor pre-bid conference to review available, used Lonnie's Pond Aquaculture gear	November	YR1 and as needed
Town selects Aquaculture Contractor	December 1	YR1 and as needed
Town publicly advertises Monitoring Contractor RFP	January	YR1 and as needed
Town grants license to Aquaculture Contractor following MassDMF certification of the Town license	January/February	YR1 and as needed
Town and Aquaculture Contractor obtain RDA or NOI from Conservation Commission	January/February	YR1 and as needed
Town selects Monitoring Contractor	February 15	YR1 and as needed
Aquaculture Contractor Actions		
Aquaculture Contractor confirms to Town that sufficient Year 1 seed oysters will be delivered	By December 31	Annually
Aquaculture Contractor deploys oysters	no later than June 1 (Scenario A) or July 1 (Scenario B)	Annually
Aquaculture Contractor removes oysters and gear	Between November 15 and December 15	Annually
Monitoring Contractor Actions		
Monitoring Contractor completes and submits Nitrogen Management QAPP to Town and MassDEP	February/March	Every 3 years
Monitoring Contractor measures initial shellfish N content through coordination with Aquaculture Contractor	Collection at time of deployment	Annually
Monitoring Contractor completes sampling every two weeks	June 15 to September 15	Annually
Monitoring Contractor installs and maintains continuous monitoring devices	Late May/early June to September	Annually
Monitoring Contractor submits and publicly presents Lonnie's Pond Aquaculture/Semi-Annual Status Update	By July 30	Annually
Monitoring Contractor measures sediment N removal	August	Annually
Monitoring Contractor measures harvest shellfish N content	Late Fall	Annually
Monitoring Contractor measures sediment N removal	October	Annually
Monitoring Contractor submits and publicly presents draft Lonnie's Pond Aquaculture/TMDL Annual Report	By December 31	Annually
Monitoring Contractor submits final Lonnie's Pond Aquaculture/TMDL Annual Report	By January 31	Annually

VI. Lonnie's Pond Aquaculture and Nitrogen Management Plan Organizational Chart



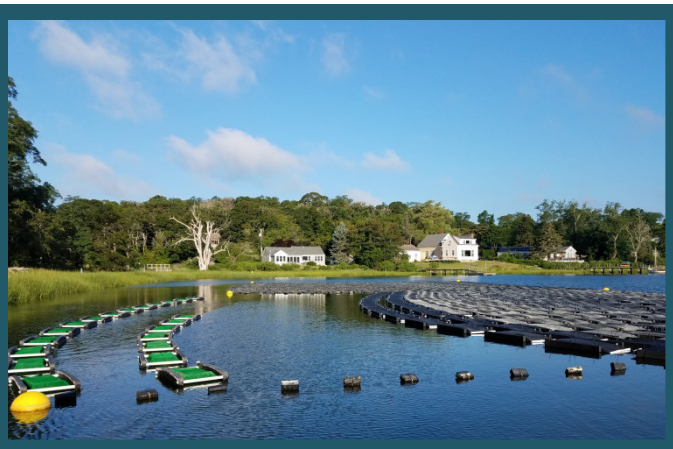
Appendix A. AECOM Lonnie's Pond Aquaculture Management Plan. Final. January 2018.

Appendix B. Coastal Systems Program, School of Marine Science and Technology (CSP/SMAST), University of Massachusetts-Dartmouth, Lonnie's Pond Shellfish Demonstration Project: Year 2 Monitoring Summer/Fall 2017 Oyster Deployment. September 2018.

Lonnie's Pond Aquaculture Management Plan

Town of Orleans, MA | Water Quality and Wastewater Planning

August 4, 2017
Revised December, 2017
Final January 2018



AECOM

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Executive Summary

In 2016, the Town of Orleans initiated a three year oyster Demonstration Project in Lonnie's Pond. The Demonstration Project is an outcome of planning efforts, including the Cape Cod Commission's 208 Plan Update, a Consensus Plan, and subsequent amendments to the Town's 2010 Comprehensive Wastewater Management Plan, which identified the need to improve water quality in coastal waters surrounding Cape Cod. The overall purpose of the Demonstration Project is to assess the effectiveness of using aquaculture to remove nitrogen from the water as a component of the Town's strategy to meet TMDL requirements and total nitrogen load reduction targets. Lonnie's Pond was identified as the preferred location for the town's first shellfish Demonstration Project based on a few key factors, including: the town's strong desire to improve the environmental conditions in the town's terminal ponds, many of which include anoxic, muddy sediments; and the expected ability to monitor water quality and other impacts caused by shellfish in this semi-closed sub-embayment.

The goals of this management plan are to summarize activity to date at Lonnie's Pond and identify management tasks between now and the end of the three-year Demonstration Project, including acquisition and disposition of shellfish, installation and monitoring of shellfish and water quality in Lonnie's Pond, budgeting, and long-term considerations for an aquaculture program in Lonnie's Pond.

Nearly 200,000 First Year (Y1) and Second Year 2 (Y2) oysters were deployed in Lonnie's Pond on June 22, 2016. Y1 are those oysters beginning the year as seed oysters approximately 2 to 3 mm in size and growing throughout one season. Y2 are those oysters that are in their second year of growth. The oysters were placed in floating bags containing 250 oysters each that were installed in an 80 foot by 120 foot system. Each bag contained 250 oysters. The bags were maintained on a weekly basis during the peak impairment season of July and August and then bi-weekly for the remainder of the growing season. Monitoring occurred every two weeks between June 2016 and December 2016. Monitoring consisted of assessing growth rate of 25 to 30 oysters that were randomly selected from each of seven tracking bags. The weight, length, and volume of the oysters were recorded. In addition, the oysters were monitored for mortality.

The oysters in the Lonnie's Pond demonstration grew well and at a rate that is typical for Cape Cod oysters during the first year of the demonstration. The Y1 oysters finished the season at an average length of about 74 mm (2.9 in) and an average weight of 35 g (1.23 oz.). The Y2 oysters finished at an average length of about 94 mm and an average weight of about 69 g (2.4 oz.). All of the Y2 oysters and approximately 80 percent of the Y1 oysters reached either petite or regular market size by the end of the Demonstration Project season, which started later than the normal growing season would. The live weight of the oysters increased from approximately 2,176 metric tons at the beginning of the project in June to approximately 10,091 metric tons at the end of the growing season (adjusted for 6.6 percent measured mortality prior to overwintering).

To measure the nitrogen content of the shell and dry weight tissue of the oysters, the samples were sent to the Boston University Stable Isotope Laboratory. The nitrogen content for Y1 and Y2 was 10.5 percent and 10.3 percent, respectively. The preliminary assessment indicates that the demonstration system removed 25.9 kg of nitrogen by uptake (increased biomass). The demonstration monitoring project in Lonnie's Pond provided data indicating that nitrogen reduction was achieved, which is a goal of the TMDL established by MassDEP for Lonnie's Pond.

Between 2016 and 2017, the oysters were overwintered in Lonnie's Pond in a system designed to keep oysters from sinking into soft sediment, avoid ice damage, maintain enough flow for the cold weather metabolic activity of oysters, and control mortality from predation. The oysters were resurfaced in mid-April 2017 and removed from the bags and assessed for mortality. Overall, the mortality rate for Y1 oysters from June 2016 through the resurfacing in 2017 was less (1.1 percent) than the Y2 oysters (10.9 percent). The total live weight of the oysters was measured and a representative sample of individuals was weighed and measured to assess growth during the winter period. These oysters were then used as a part of the second year demonstration. Year 2 oysters from the 2016 season, now three years old, were relayed to Falmouth, MA; approximately 113,000 oysters were relayed to Falmouth, MA with the intention that Falmouth, MA would return the same number of harvestable size oysters in fall 2017. However, due to oyster losses in Falmouth, MA, Orleans, MA and Falmouth, MA mutually agreed that 113,000 harvestable size quahogs would be returned in lieu of oysters. These quahogs were made available for residential family harvest.

The Demonstration Project was continued for a second year in late spring of 2017. Both Y1 and Y2 oysters were deployed in bags in a similar system as 2016. The population of oysters for the second demonstration year consisted of oysters from the first year of the Demonstration Project (former 2016 Y1 oysters), 480,000 two mm oyster seed from Mook Sea Farms, and 58,000 two inch oysters from Falmouth, MA. The total number of oysters deployed in the second year was approximately 607,000 oysters. Year 2 oysters were installed in 510 bags with a targeted final grown-out stocking density of 250 oysters per bag. Over the course of the 2017 growing season, the density of Y1 oyster bags was adjusted as their size increased, for a final grown-out density similar to the Y2 oysters.

Science Wares' monitoring in Year 2 included data collection to further refine the relationship between live wet weight and nitrogen content to provide a tool for quantifying estimated nitrogen removal by oysters without analyzing the nitrogen content of dry shell and tissue. These results will be included in the Year 2 report, due to be released in draft form in late January 2018.

The demonstration monitoring project in Lonnie's Pond data showed that oysters are achieving nitrogen reduction. The results from year one of the project indicate that oysters are removing nitrogen and could be used to meet part or all of the TMDL requirement in regard to nitrogen reduction. The oysters removed sufficient nitrogen through uptake alone. Mortality was low and the bag and line system and overwintering installation provided sufficient protection from predation and supported strong oyster growth. Year 2 and Year 3 of the Demonstration Project in Lonnie's Pond will provide additional data to evaluate the effectiveness of this non-traditional technology.

Year 3 of the demonstration project is proposed to be designed similarly as Year 1 and Year 2 but oysters in the Y1 field will be deployed in a system that is half the size of a full scale operation. These oysters are intended to validate the ability of Y1 focused scenarios to meet TMDL and MEP requirements. The field of Y2 oysters is proposed to remain the same as in 2017 with approximately 130,000 oysters. Maintenance and monitoring are proposed to be the same as in previous years, with bi-weekly measurements taken during the growing season. Samples will be sent to the BU laboratory for nitrogen analysis at the beginning and end of the demonstration year.

In fall of 2018, oysters that have been used for the Demonstration Project and are of harvestable size will be put out for harvest by residents, while smaller oysters are anticipated to be traded to Falmouth, MA for quahogs that will also be put out for harvest. It is necessary to remove these oysters from Lonnie's Pond because the oysters have incorporated nitrogen from the water column, and this nitrogen is only removed from the estuarine system when the oysters are removed from the pond.

The viability of oysters is impacted by a number of factors, including ocean acidification, predators, disease, algal blooms, biofouling and pests, storm damage, and theft. Environmental conditions should be monitored over the long term to ensure the health and survival of the oysters. Regular maintenance and the design of the system proved effective in controlling for predators and bio-monitoring to date. The overwintering system design protected from storm damage to date.

Biodeposition has not been approved by MassDEP as an approach to meet nitrogen targets. However, monitoring results indicated that it should supplement nitrogen removal by uptake. Further use of the biodeposition model to predict denitrification in Lonnie's Pond is warranted, however this management plan focuses on removal by direct uptake.

A number of scenarios are under consideration for full-scale implementation subsequent to 2018. It is estimated that the MEP nitrogen reducing goal for Lonnie's Pond (660 lbs/yr or 300 kg/yr) could be met by growing and harvesting Y1 oysters annually or by growing a combination of Y1 and Y2 oysters in a larger area of the pond, with oysters removed when they are of harvestable size. The selected scenario will be determined based on review of the last two years of data as well as the status of the MassDEP approval of aquaculture as part of a Watershed Permit and associated Watershed Management Plan.

1.0 Introduction

1.1 Background

1.1.1 Cape Cod Commission 208 Plan

Massachusetts Department of Environmental Protection (MassDEP) directed the Cape Cod Commission to update the 1978 Water Quality Management Plan in accordance with Section 208 of the federal Clean Water Act. The updated was necessary due to the impairment of water quality in coastal waters resulting from excess nitrogen. The plan was prepared by the Commission and 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. Among these were 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.

Following the update to the 208 Plan, a Consensus Agreement was developed under the guidance of the Orleans Water Quality Advisory Panel (OWQAP), which convened in 2014 to achieve consensus and build widespread community support for a customized, affordable water quality management plan for Orleans. The Consensus Agreement led to the preparation of an Amended Comprehensive Wastewater Management Plan,

1.1.2 Orleans Amended CWMP

In 2010, a Comprehensive Wastewater Management Plan (CWMP) was prepared that proposed to meet state and federal mandates through an expansion of the municipal sewer system under an Adaptive Management Plan.

The Amended CWMP was developed to provide the Town of Orleans with an alternative, more cost effective strategy for managing wastewater and reducing nitrogen in the Rock Harbor, Nauset Marsh, Pleasant Bay, Namskaket, and Little Namskaket Watersheds. This strategy included a hybrid approach to managing wastewater through a combination of traditional (sewered) technologies and several non-traditional technologies.

1.1.3 Non-Traditional Technologies

Non-Traditional nitrogen control strategies can reduce the volume of wastewater that requires treatment at wastewater treatment facilities and result in lower treatment costs for the Town. The Consensus Agreement recommended three Non-Traditional 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 (PRB). An additional innovative Non-Traditional Technology, a Nitrogen Reducing Biofilter (NRB), was also considered for implementation in areas of Orleans.

1.1.4 Aquaculture/Shellfish Propagation

Orleans chose to include shellfish propagation as a means to reduce the amount of nitrogen entering watersheds where sewering was not currently planned. Four different Demonstration Projects were discussed and planned in order to obtain site specific information within Orleans' waterbodies and the viability of pursuing full-scale implementation. The Demonstration Projects were scaled to allow meaningful monitoring and quantifiable results, while expending only the minimal amount of necessary funds during this experimental phase. The purpose of the Orleans shellfish demonstrations is to both locally measure the nitrogen-removal benefits of shellfish cultivation as well as to demonstrate the practical applications of shellfish propagation and aquaculture expansion within the Town of Orleans.

1.1.5 Lonnie's Pond

Potential demonstration sites for non-traditional technologies were systematically evaluated and ranked using a site selection matrix that included criteria for site suitability, permitting, and project evaluation. Initially, Lonnie's Pond was not evaluated by the Shellfish Team during the site selection process because it was selected by as the best alternative for Floating Constructed Wetland implementation. Once the Town put implementation of the Floating Constructed Wetland technology on-hold until further refinement of estuarine nitrogen removal and costs were evaluated, Lonnie's Pond was identified as the preferred location for the town's first shellfish Demonstration Project. This selection 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 sub-embayment.

At the time of the preparation of this plan, Year 1 (Y1) of the oyster Demonstration Project at Lonnie's pond had been completed and the growing season of Year 2 (Y2) was underway. Work completed to date, including the installation, monitoring, overwintering, and analysis of 200,000 oysters, is summarized in the following sections of this management plan. The remaining work of the Demonstration Project includes monitoring and data collection for Y2, installation, monitoring, and data collection for Year 3 (Y3), and an assessment of considerations for full-scale aquaculture at Lonnie's Pond. A discussion of this work is included in the following sections of this management plan.

1.2 Goals and Organization of Document

The goals of the document are to summarize activity to date at Lonnie's Pond to date and identify remaining actions between now and the end of the three-year Demonstration Project. Remaining actions include:

- Important decision points such as acquisition of oysters for additional years of investigation;
- Disposition of shellfish at the conclusion of each season;
- Budgeting for the remaining years of the Demonstration Project; and
- Long-term considerations and next steps for maintaining an aquaculture program in Lonnie's Pond, and potentially other terminal ponds in Orleans.

The introduction of this document, Section 1, describes past plans and activities that led up to the planning and installation of a Demonstration Project at Lonnie's Pond. Section 2, Section 3, Section 4, and Section 5 provide an overview of the planning and implementation of the three year Demonstration Project. A description of the planning, installation, monitoring program and results, and overwintering for Y1 is included in this document. At the time this document was prepared (August 2017), Y2 of the demonstration at Lonnie's Pond was underway and sampling results were not yet available. Additional details about the demonstration field, installation, and monitoring can be found in the Technical Memorandums titled *Demonstration Project Year 1 Project Report* (2/17/17) and *Draft Aquaculture Full-Scale Implementation Program* (7/7/17).

A discussion of oyster viability considerations, including disease, pests, and environmental threats, is included in section 6 of this document. Section 7 provides an overview of the results of water quality monitoring from Year 1, which is described in more detail in the memorandum *Demonstration Project Year 1 Project Report.*

The final sections of this document review considerations for full scale aquaculture at Lonnie's Pond as well as other opportunities for shellfish aquaculture and coastal habitat restoration.

1.3 Town Organization

1.3.1 General

The Lonnie's Pond Demonstration Project and Full Scale Implementation is an outcome of planning efforts, including the Cape Cod Commission's 208 Plan Update, a Consensus Plan, and subsequent amendments to the Town's 2010 Comprehensive Wastewater Management Plan, which identified the need to improve water quality in coastal waters surrounding Cape Cod. The organization for the Project is shown on Figure 1-1.

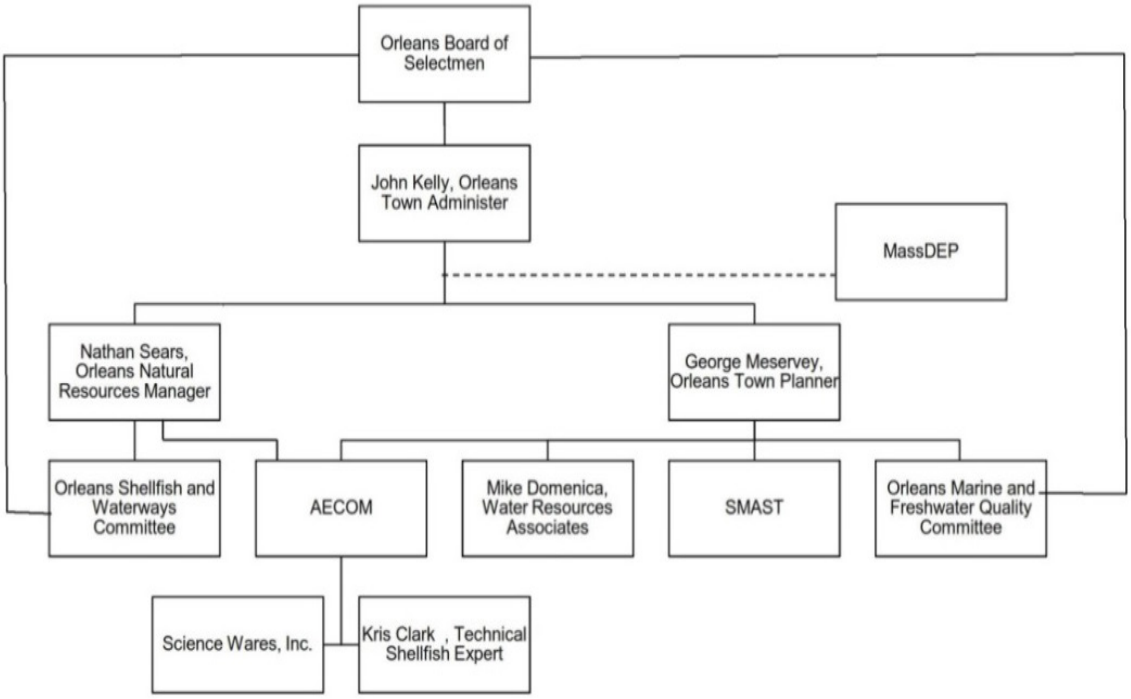


Figure 1-1 - Organizational Chart for Lonnie's Pond Demonstration

1.3.2 Board of Selectmen

The Board of Selectmen has a delegate who coordinates with the Committee and apprises the Board of status of the Lonnie's Pond aquaculture project, as well as any issues requiring decisions and resolution. The Board of Selectmen considered the Lonnie's Pond Management Plan in fall 2017 and voted to place an item on the Warrant for the fall 2017 Town Meeting for approval of funding for the spring 2018 portion of Y3 of the Demonstration Project. Prior to consideration of the budget at Town meeting, the Finance Committee reviewed the proposed budget and informed citizens of Orleans of its findings and recommendations. This is discussed in further detail in Section 5.7.

1.3.3 Shellfish and Waterways Improvement Advisory Committee Review

The Shellfish and Waterways Improvement Advisory Committee (the committee) serves as an advisor to the Town Administrator, Board of Selectmen, Harbormaster/Shellfish Constable, and other Town boards and committees. The Town calls upon this committee for issues related to preserving, protecting, managing, and enhancing natural resources, including shellfish and waterways. It is the committee's role to review the progress of, and provide recommendations as needed, in regard to the oyster Demonstration Project and Full Scale Implementation at Lonnie's Pond. The Committee provides recommendations to Nate Sears, Orleans Natural Resources Manager and the Board of Selectmen. In fall 2017, the Committee reviewed a draft version of the Management Plan and made a recommendation to Nate Sears and the Board of Selectmen to continue with Year 3 of the oyster Demonstration Project at Lonnie's Pond Board of Selectmen Review,

1.3.4 Town Meeting Budget Approvals

The Board of Selectmen submitted a Warrant Article for the fall Town Meeting, and citizens voted to approve the budget for spring 2018 Demonstration Project work on October 24, 2017. Ongoing budgets for the Lonnie's Pond aquaculture will be subject to approval at future Town Meetings as appropriate.

2.0 Lonnie's Pond Demonstration Project Planning

Orleans is pursuing oyster cultivation as the first demonstration because many scientific papers published in peer-reviewed journals demonstrate the nitrogen uptake and water quality improvements caused by oyster cultivation (Bricker 2015; Carmichael et al. 2004; Higgins et al. 2011; Kellogg et al. 2013, 2014; Nelson et al. 2004; Porter et al. 2004).

Oysters feed by filtering algae and other particles that contain nitrogen out of the water column. Through this filter-feeding process, oysters both improve water clarity and impact nitrogen concentrations (Newell et al. 2002, 2004, 2005; Officer 1982). Oysters remove nitrogen from the water column by filtering phytoplankton and other organic particles from the water. These inorganic materials are incorporated into the shell and soft tissue and are removed when the oysters are harvested. In the sediment, nitrogen compounds in the feces and pseudofeces are mineralized into inorganic nitrogen through oxidation to nitrates. Denitrification of nitrates releases nitrogen gas which leaves the system. A small fraction of the nitrogen is buried in the sediment and does not re-enter the water column.

Thus, the main pathways by which oysters remove the mass of nitrogen in an estuary are:

- Uptake into shell and soft tissue (which harvesting removes);
- Enhancement of sediment denitrification (nitrogen removed as a gas); and
- Packaging of particles into feces and pseudofeces (biodeposits), which sink into the estuary bottom and are not denitrified (burial).

It is important to remember that all of the nitrogen that is sequestered in the body of an oyster, as well as the nitrogen contained in biodeposits and excretions, comes originally from the water column. Therefore, following the principle of the conservation of mass, oysters do not contribute new nitrogen, but instead both sequester and reformulate the nitrogen already contained in an ecosystem. Biodeposition and excretion of inorganic nitrogen does not add any new nitrogen to the water column or estuary bottom. The nitrogen was already in the system.

Removing oysters that have grown in the water column directly removes a mass of nitrogen that was previously in the water. This nitrogen-removal value can be measured directly by weighing the shell and soft tissue and applying a measured value for the percent nitrogen contained therein. While the amount of nitrogen sequestered in the shell and tissue of adult oysters is reasonably consistent, rates of enhanced sediment denitrification vary widely and are highly site-specific (Kellogg et al. 2013). Therefore this management plan focuses on nitrogen removed via direct uptake.

There is a strong scientific basis for using oyster cultivation to decrease water column nitrogen concentration and improve water clarity. A Demonstration Projects focusing on oysters was seen as an important first step in order to validate the quantities of nitrogen removed through uptake in the body of the oyster. The Lonnie's Pond project provides the field-verified basis for including oyster cultivation in the Town's wastewater plans.

3.0 Lonnie's Pond Oysters Demonstration Project Year 1 (2016)

Two-hundred thousand (200,000) oysters between 1 and 2 inches in size were installed in floating bags in Lonnie's Pond in the summer of 2016. The oysters were maintained and monitored through the winter of 2016 and 2017. In April of 2017, the oysters were removed from the bags and evaluated for survival and growth. The work accomplished and results of Project Y1 are summarized below.

3.1 Field Installation

Oysters were deployed in Lonnie's Pond in an 80 foot by 120 foot system comprised of 800 floating bags that were installed along long lines spaced approximately 10 feet apart. Each floating bag contained 250 oysters. Volunteers, staff, and unpaid members of the shellfish technical team assisted with assembling and deploying the oysters, which were purchased from the Town of Falmouth, MA and Cape Cod Oyster (Table 3-1).

Table 3-1 - Oysters for Demonstration Year 1 (2016)

Size Classes	Number of Oysters	Source of Oysters	Number of Bags
Year 2 (2-inches)	127,000	Town of Falmouth, MA	560
Year 1 (1-inch)	11,700		
Year 1 (< 1-inch)	60,000	Cape Cod Oyster	240
TOTALS	**198,700**		**800**

3.2 Operation and Maintenance

In order to prevent fouling, bags were flipped on a weekly basis during the peak impairment period and bi-weekly as the growing season concluded. Tunicates (sea-squirts) and algae were found on several occasions but were controlled by the weekly flipping. Bags were flipped by boat at high tide to prevent disturbance to the bottom sediment and allow for SMAST to accurately determine denitrification rates. Flipping the bags also helped to prevent oysters from growing together and to trim edges, both of which are important for marketability. In addition, flipping the bags helps extract feces and pseudofeces.

Gear remained in-place all season and performed well overall. Minor repairs were performed as needed on the water, and primarily involved replacing broken zip-ties that held the side floats to some of the bags. On one occasion when there was a risk of a hurricane in the forecast, an additional 10-foot of length was temporarily added to the long lines to accommodate a possible storm surge increasing the water level.

The water level typically changed by several feet each the day. Scope between the end of the middle long line and the auger on each end was sufficient to allow the strings to withstand this range of water level change. On extreme tides, two to four bags located on the ends of the field would occasionally stand up on end, but the oysters would redistribute as the tide went out and the bags laid back down flat. Extended periods of wind and moon cycles could increase or decrease the average water height by about a foot. Regardless of the wind, the surface conditions were calm, and the gear was never at risk of damage due to wind or wave action.

3.3 Growing Season Monitoring

Seven floating bags were monitored for growth rates and mortality every two weeks between June and December, 2016 (total of 18 times). To assess growth rate, 25 to 30 oysters were randomly selected from each of the seven tracking bags and lightly scrubbed to remove surface fouling. Twenty-five oysters were placed on a scaled mat and photographed for measurement. The oysters were weighed as a group to determine an average weight. Individual oysters were also weighed to validate the averages. In addition, the total volume occupied by the sample was measured inside a cylindrical container with a gauge plate.

The entire oyster field was monitored for mortality during each session when bags were maintained and flipped. Two methods were used to assess oyster mortality: (1) visual inspection to look for open shells, and (2) audible inspection to listen for the distinctive rattle of a single oyster shell that could be heard when the bag was flipped. Mortality was noted during maintenance sessions, but dead oysters were not removed from the bags at that time.

The seven tracking bags were further inspected for mortality each time oysters were withdrawn for measurements, at which point any dead shells were inspected, counted, and removed. Mortality was first observed during these inspections of the tracking bags in mid-September. From mid-September through December, mortality counts were also made from additional representative bags during every other bag flip cycle. The final mortality assessment was made by counting live and dead oysters in four (4) bags of Y1 oysters and four bags of Y2 oysters that had not been previously counted. The overall final mortality rate prior to overwintering (December 2, 2016) was 6.6 percent.

3.4 Oyster Growth, Mortality, and Nitrogen Content

The oysters grew well and at rate typical of other Cape Cod locations. The Y1 oysters finished at an average length of about 74 mm (2.9 in) and an average weight of 35 g (1.23 oz.). The Y2 oysters finished at an average length of about 94 mm and an average weight of about 69 g (2.4 oz.). Approximately 80 percent of the Y1 reached harvestable size (76 mm / 3 in) in one shortened growing season (the typical season begins in May). The live weight of the oysters increased from approximately 2,176 metric tons at the beginning of the project on June 22, 2016 to approximately 10,091 metric tons at the end of the growing season (adjusted for 6.6 percent measured mortality). During the growing season, the volume requirement of the oysters increases, resulting in the need to split bags. The rate of change of volume requirement for Y1 and Y2 oysters is different, resulting in fewer bags on the water early in the season and during the critical impairment period of July and August for Y1 oysters as well as a lower visual impact from late June to early September.

Samples were sent to the Boston University Stable Isotope Laboratory to determine the nitrogen content of the shell and dry weight tissue. The nitrogen content for Y1 and Y2 was 10.5 percent and 10.3 percent, respectively Table 3-2). The preliminary assessment indicates that the demonstration system removed 17.3 kg of nitrogen by denitrification (about 67 percent of the amount removed through tissue and shell uptake) and 25.9 kg of nitrogen by uptake (increased biomass). A summary of oyster weights and nitrogen update from Y1 is displayed in

Location	Sample Time	Length (mm)	Whole Weight (g)	Dry Tissue Weight (g)	Total N, Shell and Tissue (g)	N as a percent of Dry Tissue Weight (%)
Y2 Lonnie's Incoming	Spring	62.9	17.73	0.66	0.0683	10.3
Y2 Lonnie's New Growth	Fall	100	80.4	2.49	0.257	10.3
Y1 Lonnie's New Growth	Fall	74.3	37.4	1.20	0.126	10.5

Table 3-3.

Table 3-2 - Total Nitrogen Content of Lonnie's Pond Oysters

Location	Sample Time	Length (mm)	Whole Weight (g)	Dry Tissue Weight (g)	Total N, Shell and Tissue (g)	N as a percent of Dry Tissue Weight (%)
Y2 Lonnie's Incoming	Spring	62.9	17.73	0.66	0.0683	10.3
Y2 Lonnie's New Growth	Fall	100	80.4	2.49	0.257	10.3
Y1 Lonnie's New Growth	Fall	74.3	37.4	1.20	0.126	10.5

Table 3-3 - Oyster Weights and Nitrogen Uptake from 2016 Demonstration by Installation Size Class

Oyster	Dry Tissue Weight (g)			N Uptake per Oyster (g)	Initial # of Oysters	Mortality	Total Uptake(kg)
	Initial	Final	Increase				
Y1	0.055	1.04	0.98	0.103	60,000	6.6%	5.81
Falmouth, MA Small	0.055	0.79	0.74	0.076	11,700	6.6%	0.84
Y2	0.562	2.12	1.56	0.160	126,690	6.6%	19.41
Totals					**198,390**	**6.6%**	**26.06**

The percent of total nitrogen contained in Lonnie's Pond oysters are typical for cultured off-bottom oysters; however, the actual value may be different depending on at which point in the growing season oysters are removed from Lonnie's Pond. Additional information about seasonal variation in the nitrogen content of oysters grown to marketable size will be obtained during the second year of the Demonstration Project. It is not expected that such variations will have a substantial effect on the overall viability or costs of the program. The relationship between dry tissue weight and harvest weight will also be established in the second year in order to develop a tool for quantifying nitrogen removal over the course of the growing season and at different harvest times.

3.5 Quality Control

As stated above, samples were sent to the Boston University Stable Isotope Laboratory for nitrogen analysis. The Laboratory weighs out samples to 0.001 mg into tin capsules on a microbalance, then combusts them in an elemental analyzer and measures them using software. Check standards are inserted into the run to ensure precision and quality control. Any anomalous samples are reweighed and rerun. The precision for replicate samples is 0.5 percent for nitrogen. Boston University (BU) protocols were approved by MassDEP. Refer to the QAQC document in Appendix A for a description of the protocol.

In addition to laboratory analysis, other procedures included sampling and analyzing oysters for harvest weight and dry weight. Science Wares' Standard Operating Protocols (SOPs) for these procedures are also included in Appendix A.

3.6 Overwintering System Design and Installation

Oysters were submerged for overwintering by December 23, 2016. The overwintering system was designed to keep oysters from sinking into soft sediment, avoid ice damage, maintain enough flow for the cold weather metabolic activity of oysters, and control mortality from predation, in addition to being practical to install. The system includes a three-part PVC tube frame attached to two plastic pallets, and is illustrated in Figure 3-1. The assembly footprint is 50 in wide by 82 in long by 57 in high and requires a minimum water depth of six feet. The negative buoyancy and nine wedge-shaped feet of each assemble prevent the loaded assembly from

descending into soft bottom. Copper barriers were applied to some of the frames to discourage drills from traveling along the supports to reach the bags. This system made it possible to leave the oysters in the grow-out bags for overwintering, and is advantageous because it:

- Allows oysters to continue to filter water;
- Maintains water flow across the oysters to enable survival and prevent toxicity as oysters continue to filter and purge over the winter;
- Minimizes the handling of oysters that could damage the shells and lead to higher mortality over the winter; and
- Provides a physical barrier (6 mm bag mesh, copper wire) against mature drills and other predators.

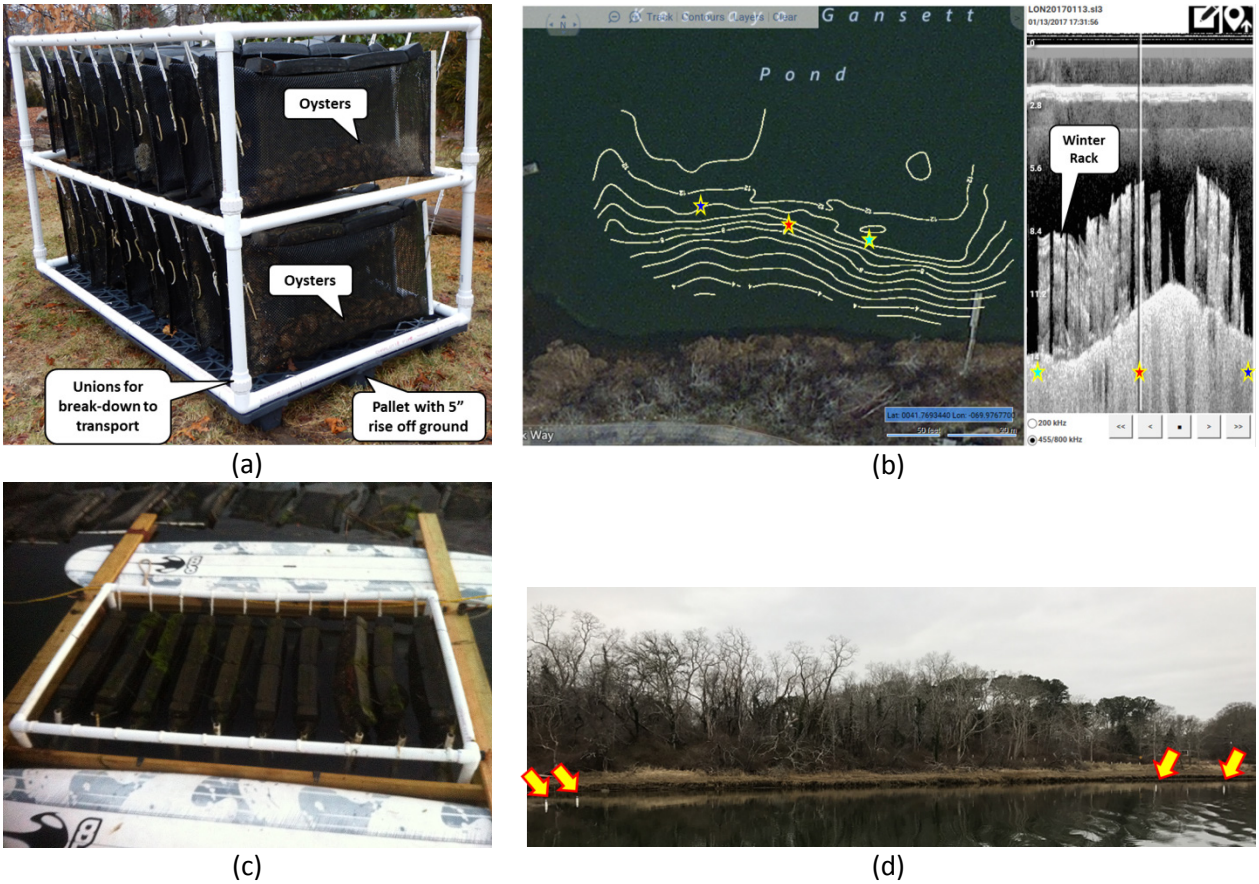


Figure 3-1. Science Wares overwintering system for 2016 Demonstration Year at Lonnie's Pond: (a) rack on dry ground showing two levels of bags oriented with one float up and oysters down (b) depth profile and sonar scan showing orientation of racks on the bottom (c) loaded rack about to be submerged (d) a view of the surface of Lonnie's Pond after all bags had been submerged, with corner markers showing the location of the overwintering racks.

A custom raft was constructed for installation of this overwintering system. Bags were installed on the racks and sunk to the bottom over the course of three days. The total biomass of oysters that were submerged was over 10,000 kg. This total weight was determined by direct measurement of oyster weights and survival. In the spring, the oysters were graded and an overwintering mortality was determined.

3.7 Winter Monitoring

Two temperature sensors were placed in different locations near the overwintering site to establish field conditions prior to overwintering. The sensors monitored water temperature at 10 minute intervals a few inches below the surface (moving up and down with the water level), and at a fixed location about a foot off the bottom near where the deepest overwintered oysters would be.

Typically oysters are kept on the surface as late into the winter season as possible, depending on environmental conditions including temperature and dissolved oxygen. Although common practice is to submerge the oysters below the surface as soon as the water temperature drops below 6°C for six days in a row, the demonstration oysters were overwintered earlier than usual due to forecasted low temperatures and risk of the water freezing at the surface. Ultimately, the water temperature at the surface did not reach -2°C, the temperature at which seawater typically freezes. The results of temperature monitoring show close tracking of the surface and bottom temperatures, highlighting two important features of Lonnie's Pond:

- A high turnover rate of water coming in from Pleasant Bay; and
- An absence of persistent stratification at the location where the oysters are being maintained.

In addition to monitoring temperature, a cluster of sensors was placed in the field of winter racks to measure temperature, water level, salinity, and dissolved oxygen at 15 minute intervals throughout the winter season. Data revealed that:

- Dissolved oxygen content does not fall below 12 mg/L, which is consistent with typical winter conditions;
- Normal cycle of tidally-influenced water levels can be affected by weather conditions, such as a northerly wind; and
- Large tidal variations (including changes of 1.65 m over a two-week period in early 2016 and typical daily oscillations of about 0.9 m and 1.2 m) indicate that there is a high rate of exchange of water with Pleasant Bay.

3.8 Resurfacing of Overwintered Oysters

The 2016 oysters were resurfaced between April 17 and April 24, 2017 after the water temperature had risen sufficiently. The oysters were brought to the surface, removed from the submerged bags, and assessed for mortality. The shells of dead oysters were separated out. The total live weight of the oysters was measured and a representative sample of individuals was weight and measured to assess growth during the winter period. These oysters were used as a part of the second year demonstration.

Table 3-4 summarizes the number of Y1 and Y2 oysters from 2016 that were processed and the mortality rate from June of 2016 through May of 2017. Year 1 oysters from the first year of the Demonstration Project (now Y2 oysters) were moved to the south side of the Demonstration Projects year two field. The Y2 oysters from 2016 (now Y3 oysters) were relayed to Falmouth, MA because they were of harvestable size but there was no location in late spring, 2017 within Orleans where they could be put out for harvest due to the time of year and lack of appropriate regulations in place at the time.

Table 3-4 - Resurfaced Oysters From 2016

Oyster Age and ID		Oysters Processed After Overwintering	Mortality Since 6/22/16	Location of Oysters in 2017
2016	2017			
Y1	Y2-L	70,769	1,320 (1.78%)	Oysters moved to south side of the Y2 field on May 4, 2017
Y2	Y3	127,346	13,772 (10.8%)	113,574 live oysters relayed to Falmouth, MA

3.9 Cost

Table 3-5 displays a cost estimate for the Year 1 of the aquaculture Demonstration Project in Lonnie's Pond in 2016.

Table 3-5 - Demonstration Project Year 1

Description	Cost
Planning and Implementation (July 2016 through October 2016)	$59,680
FY17 Planning and Implementation (November 2016 through June 2017)	
Build and Install Overwintering System	$80,000
2016 Project Report	$17,000
Assemble bags	$115,000
Install oysters (June 2017)	$135,000
Monthly Operation and Maintenance	$15,000
SMAST	$28,500
TOTAL	**$450,180**

4.0 Lonnie's Pond Oysters Demonstration Project Year 2 (2017)

4.1 Field Design and Equipment

The Demonstration Project at Lonnie's Pond was continued for a second year to further refine a long-term implementation plan that that uses shellfish to remove nitrogen and to continue to collect data needed to obtain regulatory approvals for the use of shellfish aquaculture to achieve nitrogen goals. The design of Y2 Demonstration Project is similar to the Y1 project, with two plots containing Y1 and Y2 oysters (Figure 4-1).

4.2 Shellfish Acquisition and Installation

The population of oysters that was grown as Y1 in 2016 was grown for a second year in 2017. These oysters are larger than the intermediate seed available from other suppliers. These oysters have an average dry tissue weight of about 1 gram, so the equivalent initial stocking density would be 150 oysters per bag to achieve the projected Y2 performance comparable to placing intermediate seed with a 0.5g dry tissue weight at an initial stocking density of 280 per bag.

Additional seed was ordered to continue the Demonstration Project, including:

- 480,000 2 mm oyster seed from Mook Sea Farms; and
- 58,000 2 inch (i.e. overwintered Y2 oysters) was ordered from Falmouth, MA.

Approximately 607,000 oysters, including 127,000 Y2 oysters and 480,000 Y1 oysters were deployed in two plots in Lonnie's Pond. The Y2 oysters were deployed in 510 bags with a targeted final grown-out stocking density of 250 oysters per bag in the west (W) plot (Figure 4-1).

Y1 oysters were grown from 2 mm seed in spat bags in the east (E) plot shown in Figure 4-1. The number of bags and Y1 oysters occupying each bag was adjusted over the growing season to accommodate oyster growth. It is anticipated that there will be 510 bags of Y1 oysters at the end of the growing season. The number of bags and initial stocking density for Y1 and Y2 oysters targets a final population of 250 per bag.

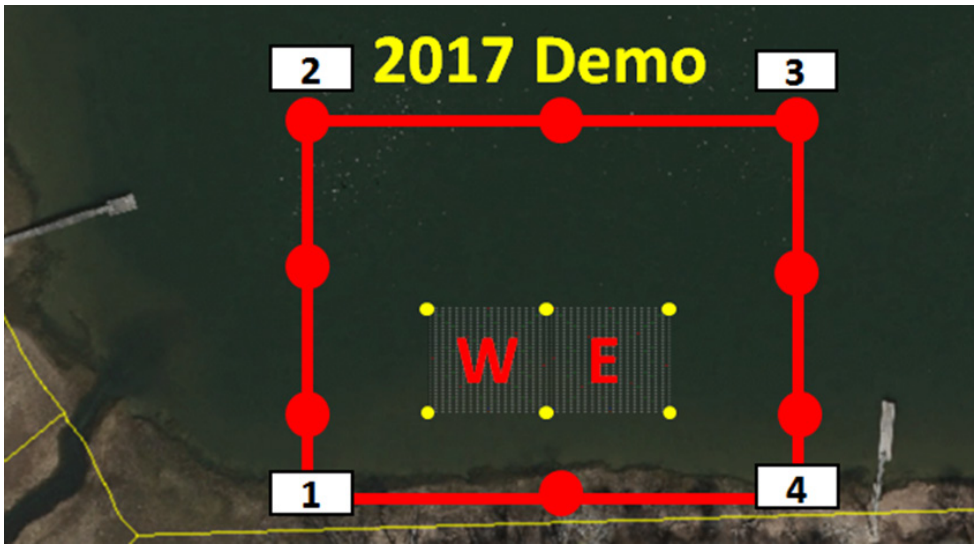


Figure 4-1 - Year 2 (2017) Demonstration Field

4.3 Maintenance and Monitoring

As in 2016, the 2017 management measures consist of flipping the bags on a weekly basis at beginning of the growing season and bi-weekly later in the season as growth begins to curtail. Gear will continue to be maintained and repaired as needed.

4.4 Disposition of Excess Oysters

All of the Y1 oysters from the 2017 Demonstration Year will be overwintered and re-deployed in spring 2018. Approximately 100,000 harvestable size oysters were removed from Lonnie's Pond in November 2017 and transported to the Town Landing on Route 28 for harvest by residents with a family harvest license. In addition, arrangements are underway to receive approximately 113,000 harvestable size quahogs from Falmouth, MA for residential harvest, in exchange for the 113,000 harvestable size oysters that were provided to Falmouth, MA in spring, 2017.

4.5 Shellfish Data Collection and Reporting

Similar to 2016, oysters were monitored for growth and mortality. Fourteen bags of Y2 oysters and 2 to 3 percent of the Y1 bags were monitored for weight and mortality on a weekly basis. During each monitoring session, 15 oysters were extracted from a different bag each time at approximately two-week intervals for size, harvest weight, and dry tissue weight analysis. Similar measurements will be made of the oysters in the Y1 field once they have a harvest weight of approximately 5 grams each. The weights and lengths were measured in the same manner as in the first year of the Demonstration Project.

At the end of the sampling period 25 oysters will be randomly selected and analyzed for nitrogen content at the Boston University laboratory. Based on the data collected in Y1 and Y2, a tool will be developed to allow the nitrogen content of live wet oysters to be estimated, which will be necessary for future quantification of nitrogen removal at full scale implementation.

4.6 Additional Activities

Additional activities in Year 2 of the Demonstration Project include:

- Work with SMAST to obtain food availability, biodeposition, and denitrification enhancement measurements from suitable locations before, during, and after the critical impairment period of July and August; and determine the feasibility of measuring the difference, if any, in the denitrification rate if maintenance is done on foot as opposed to by boat;

- Evaluate public and abutter acceptance by person interviews and/or surveys;
- Evaluate acceptance and compatibility with other local growers and commercial shellfish harvesters by personal interviews and/or surveys;
- Review the options with DMF for sale by the Town of intermediate seed;
- Identify any permitting issues for a commercial site license (grant) in Lonnie's Pond; and
- Investigate permitting for intermediate seed sale by growers

4.7 Cost

Table 4-1 displays a cost estimate for the aquaculture Demonstration Project in Lonnie's Pond for the second year of the demonstration. Y2 costs include labor for deploying, maintaining, monitoring, overwintering, and reconditioning the bags. Project management, engineering, and a final report are included. Oyster seeds were also purchased to supplement the existing supply of overwintered oysters (2016 Y1) oysters. Finally, lab costs for the nitrogen analysis are included.

Table 4-1 - Demonstration Project Cost in Year 2

Description	April - June 30, 2017	July 1 - Dec 31, 2017
Project Management	$18,000	$21,000
Engineering	$22,500	
Labor		
Overwintered Oyster Processing Labor	$14,400	
Labor for bags and fixed field alignment gear	$11,000	
2017 Oyster Deployment Labor in Lonnie's	$10,000	
Flip & Maintain Labor	$2,000	
First split Labor		$1,000
Second split Labor		$1,000
Flip & Maintain Labor		$5,000
Overwintering Labor		$5,000
Y2 Bottom Planting Labor		$2,000
Labor to recondition 500 winter bags		
Half Scale Y1X Deployment Labor		
Field sampling & sample prep	$7,680	$0
Analysis of Monitoring Data		$7,800
Permit Options Analysis		$1,000
Lab		
N analysis	$2,600	$7,800
Oyster Seed		
2 to 3mm oyster seed	$5,760	
Intermediate oyster seed	$12,760	
Materials		
Spat bags	$1,920	
Materials for two 500 bag fixed fields	$8,320	
Materials & supplies for sampling	$2,180	$6,600
Materials for 1,000 bags & lines		
Materials to recondition 500 winter bags		
Year 2 Final Report		$30,000
Contingency	$10,700	$6,200
SMAST Water Quality Sampling		$67,000
TOTALS	**$129,820**	**$161,400**
		$291,220

5.0 Lonnie's Pond Oysters Demonstration Project Year 3 (2018)

5.1 Field Design and Equipment

The layout of the 2018 Y3 of the Demonstration Project is illustrated in Figure 5-1. The northwest (NW) and southwest (SW) fields are Y2 oysters, the southeast (SE) field is comprised of Y1 oysters, and the northeast (NE) field would be comprised of a combination of Y1 and Y2 oysters.

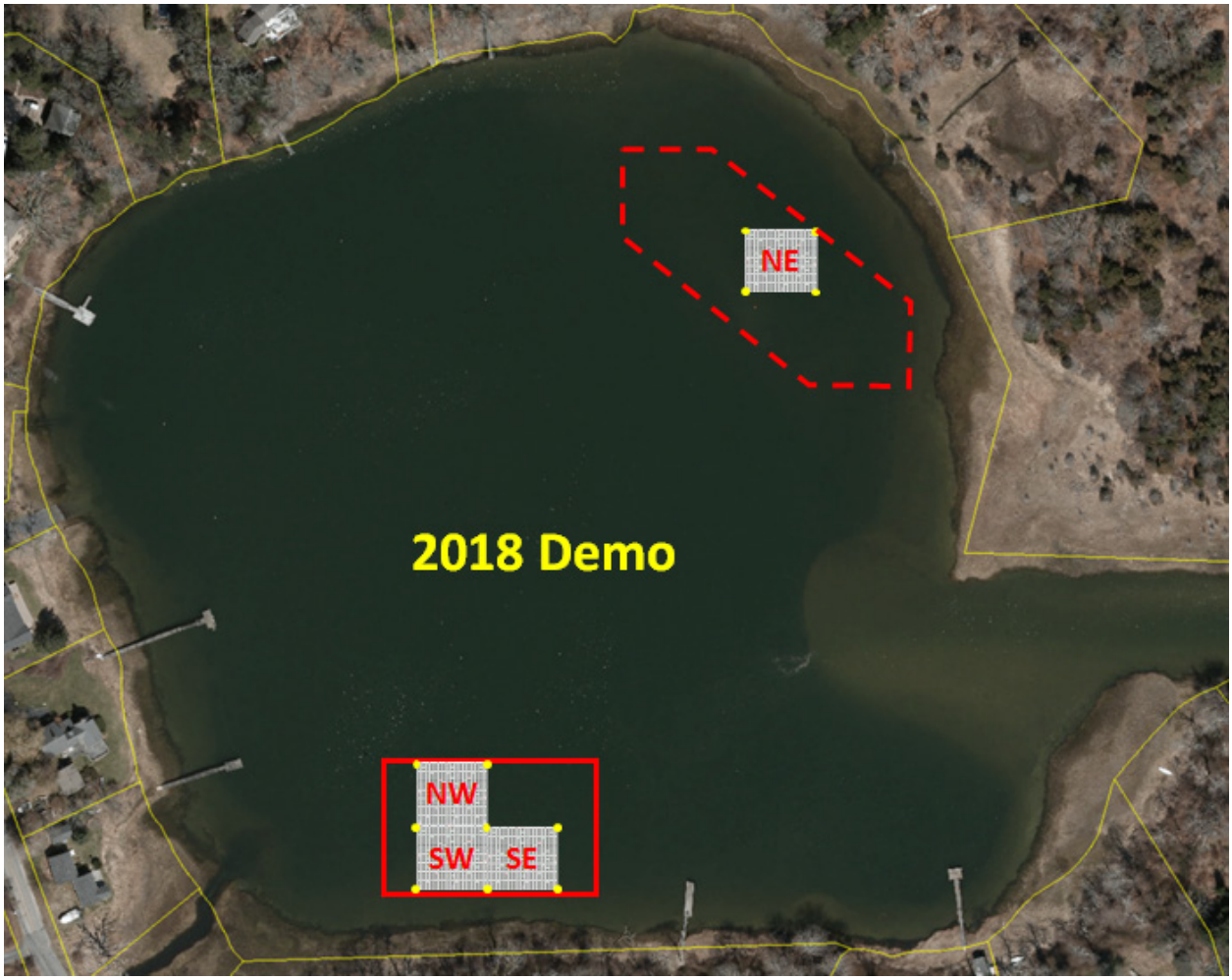


Figure 5-1 - Year 3 (2018) Demonstration Field

The design of the Y3 Demonstration Project is recommended to be approximately twice as big as the 2017 Y2, and approximately half of a full scale implementation scenario that would achieve 100% compliance with the MEP Nitrogen removal goals. The larger design is planned because it will facilitate evaluation of a deployment in which Y2 oysters occupy the majority of the deployment space to verify their nitrogen uptake in a high density layout. In addition, the expanded layout involves installing an oyster field in the northeast part of the pond, where oyster fields would be required if full scale implementation were to meet 100 percent of the MEP nitrogen removal goals. The 2018 layout will provide additional data to validate assumptions made for all scenarios currently under consideration for scale implementation depending on scenario ultimately selected (see Section 9.0).

The bags needed for the 2018 Y2 oysters would include a total of 2,040 6 mm diamond mesh bags, which will consist of the following:

- 1,020 from demo Year 2 (the 2017 growing season);
- 800 from the demo Year 1 (the 2016 growing season) which need to be reconstructed; and
- 220 new bags.

In addition, 360 spat bags will be needed for grow-out of the 2.04 million 2 to 3 mm seed until they can be kept in 6 mm diamond mesh bags:

- 80 bags from demo Y2 (the 2017 growing season) can be reused but will need new internal frames; and
- 100 new bags will need to be constructed.

5.2 Shellfish Acquisition and Installation

The Y1 and Y2 oysters for the third year of the Demonstration Project will be obtained from a combination of 2017 Y1 oysters that will be Y2 in 2018 after overwintering, as well as additional procurement of Y1 oysters in 2018 from an outside source. For the Y2 oysters needed in Lonnie's Pond in 2018, all of these are anticipated to be provided by overwintered Y1 oysters. For the 1,060,000 Y1 2018 oysters, all of these would need to be procured from a nursery in spring 2018, which necessitates submitting a request for procurement in December 2017 and submitting a deposit to secure delivery in the spring.

5.3 Management Measures

5.3.1 Equipment Monitoring and Maintenance Tasks

As in 2017, the 2018 management measures will consist of flipping the bags on a weekly basis at beginning of the growing season and bi-weekly later in the season as growth begins to curtail. As needed, gear will be repaired. Only minor repairs are anticipated to be needed, such as replacing broken zip-ties that hold the side floats to the bags, although bi-weekly inspections will occur to monitor the oyster fields and make any repairs needed. As in past years, work will be performed from kayak/skiff in order to avoid disturbance of the bottom sediments to facilitate the SMAST sampling that is ongoing.

5.3.2 Additional Permitting

Permitting requirements for 2018 are anticipated to be similar to those that were required in 2017. The Negative Determination of Applicability obtained from the Orleans Conservation Commission for the 2017 work was only valid for the 2017 year of the Demonstration Project, including the overwintering between 2017/2018. Therefore, another Request for Determination of Applicability (RDA) or a Notice of Intent (NOI) will need to be submitted to authorize deployment of the proposed oyster fields in spring 2018.

5.3.3 Shellfish Data Collection and Reporting

Shellfish data collected will be similar to 2017. Approximately bi-weekly between May 1 and December 1, 25 oysters from the 7 selected sampling bags will be removed for weight and length measurements in the field. Weights and lengths will be measured in the same manner as in past years. In addition, 25 oysters will be collected at the beginning and end of the sampling period and analyzed for nitrogen content at the Boston University laboratory.

5.3.4 Shellfish Disposition

Disposition of oysters at the end of the 2018 season will be dependent upon the status of MassDEP approval of aquaculture as part of a Watershed Permit and associated Watershed Management Plan, as discussed in greater detail in Section 9.1. Potentially, the shellfish remaining at the end of 2018 could be used in an ongoing demonstration or full-scale project, or put out for harvest if they are of harvestable size. In addition, arrangements are underway to arrange for an exchange of excess Y1 oysters with Falmouth, MA, in return for harvestable size quahogs from Falmouth, MA.

5.4 Cost

Costs for the 2018 Y3 of the Demonstration Program are envisioned to include the following:

- Labor and materials to overwinter the required number of Y1 oysters;
- Acquisition of required number of 2 to 3 mm seed;
- Labor and materials to deploy the Y1 and Y2 oysters;
- Labor to operate and maintain the four fields of oysters between May and November 2018;
- Labor to collect length, weight, and nitrogen measurements; and
- Labor to prepare the year-end report (Table 5-1).

Based on the 2017 invoice the cost for 2 to 3 mm seed would be $13 per 1,000, for a total of $26,500. A 50 percent deposit of $13,250 is required by December 31, 2017 to get early seed for 2018; a second payment on delivery of $13,250 in May 2018 will be required. The complete summary of costs for Y3 is shown in Table 5-1 below.

Table 5-1 - Demonstration Project Cost in Year 3

Description	Jan 1 - June 30, 2018	July 1 - Dec 31, 2018
Project Management	$ 44,200	$47,400
Process Engineering & Optimization	$ 12,000	$6,000
Labor		
Overwintered Oyster Processing Labor	$ 11,220	$11,220
Labor for bags and fixed field alignment gear	$ 16,900	
2017 Oyster Deployment Labor in Lonnie's	$ 11,220	
Seed Flip & Maintain Labor	$ 1,320	$1,980
Seed Splitting Labor	$ 8,360	$7,920
Seed Deployment Labor	$ 3,960	
Bag Flip & Maintain Labor	$2,250	$11,130
Field sampling & sample prep	$ 20,020	$34,320
Y2 Bottom Planting Labor		$4,490
Lab		
N analysis	$ 3,110	$9,310
Materials		
Materials & Supplies for Sampling	$ 1,000	$3,060
New floating spat bag materials	$ 3,940	
Materials for four 510 bag fixed fields	$ 9,650	
Purchase of 2 to 3 mm seed	$26,500	
Permitting	$ 5,000	
Year 3 Final Report		$30,000
TOTALS	**$180,650**	**$166,830**
		$347,480

5.5 Key Actions and Associated Dates

Key decisions for Y3 of the Demonstration Project in 2018 are summarized in Table 5-2, along with the date by which each decision is needed.

Table 5-2 - Key decisions for Year 3

Key Decision Point	Critical Date
Prepare Notice of Intent for Conservation Commission for Implementation of Year 3	January 2017
Put excess 2017 Oysters out to Harvest	November, 2017
Place Deposit on Order for 2018 Seed Shellfish for Year 3 Demonstration Project	December 31, 2017
Prepare Y1 oysters for overwintering	December 2017
Place Final Order for 2018 Year 3 Shellfish	April 1, 2018
Confirm FY 2018 Budget and Include for Town Meeting Approval	February, 2018
Receive early start seed and establish bags	May 1, 2018
Deploy Y2 field	May 1, 2018
Contact Falmouth, MA to arrange for exchange of oysters and shellfish	January 1, 2018
Evaluate status of DEP discussions and whether to continue with Demonstration Project, expand to full scale, or curtail program	Summer 2018
Identify number and location for harvestable oysters	October 2018
Inventory Overwintering and Deployment Equipment and Identify Storage/Disposition	October 2018

6.0 Oyster Viability Considerations

6.1 Ocean Acidification

Tracking the acidity (pH) of the growing area will enable a grower to be aware if concerns for ocean acidification are warranted. Primarily a cause for concern at shellfish hatcheries where young oyster larvae and juvenile seed are reared, acidity of estuarine waters is not expected to interfere with growing oysters. But tracking the pH, not only through the year, but over the past few years would give information about the pH trend so that a response can be developed.

It is likely that responses are severely limited should pH start trending down significantly. Any large-scale buffering attempts done in Lonnie's Pond would have to go through the Orleans Conservation Commission and would likely be challenged at that level. But if acidity begins to be a problem, it would not likely be in the near future and a lot may change in Lonnie's Pond and in regulations by then.

One response could be that younger, more vulnerable oysters with thin shells could be cultivated elsewhere and the older and more rugged oysters (Y2) oysters grown in Lonnie's Pond, doing the heavy lifting of the Nitrogen uptake. The overall uptake of Nitrogen in this water body would be less than is currently proposed, though, if the younger oysters weren't grown in Lonnie's Pond.

6.2 Predators

6.2.1 Crabs: Green, Blue, Calico (aka Lady), Mud, Spider, Rock, Asian Shore

Crabs can devastate an oyster crop, especially when the oysters are young. Having the oysters in floating bags off the bottom is helpful in keeping the vulnerable oysters away from the crabs' primary habitat on the bottom of the Pond. Regular maintenance of the crop to remove the crabs from the bagged oysters will serve to preserve the crop.

6.2.2 Oyster Drills

Oyster Drills may be overlooked due to being tiny and being approximately the same color as oysters in the field. Regular maintenance of an oyster crop with vigilant observations for oyster drills, oyster drill eggs and oyster drill damage can keep any loss to a minimum. Use of copper rings as a barrier on bottom structures (like the overwintering cages) can repel oyster drills from moving towards the oysters.

6.2.3 Birds: Oyster Catchers and Seagulls

Oysters can be protected from predation by these birds by being covered in cages, oyster bags and similar predation exclusion devices.

6.3 Disease

6.3.1 Juvenile Oyster Disease

This disease strikes first year oysters and is infectious. It can be minimized by making sure that the hatchery from where the seed comes utilizes good animal husbandry practices. It is expressed in the early stages of growth, from around July to September and can cause collapse of a crop in its early stage of development. Affected oyster seed exhibits cupped shells with a brown ring or deposit on the inner shell. Removing the diseased animals from the rest of the crop is advised. Moving crop to lower salinities (fresher water) can help. Obtaining seed from certified hatcheries is advised.

6.3.2 Dermo, Perkinsus marinus

Watery oyster meat is an effect of Dermo, whereby the oyster slows its growth (because of poor health) and eventually dies. Mortality is exhibited in the fall and typically affects second year oysters. Growing oysters in lower salinities helps. It's better to grow the oysters fast and sell them before diseases mature. Disease resistant oyster seed has been developed by hatcheries and has increased the survival of oysters with some prevalence of Dermo in the growing areas. Obtaining seed from certified hatcheries is advised.

6.3.3 MSX or Multinucleated Sphere Unknown, Haplosporidian Nelson

Watery oyster meat is also a hallmark of MSX. Disease resistant seed has been developed by hatcheries and has been helpful in the grow-out of oysters in the Northeast. Obtaining seed from certified hatcheries is advised.

6.4 Algal Blooms

Algal and/or seaweed mats can clog oyster growing gear, limiting the amount of oxygenated water and phytoplankton (microalgae) from feeding the oysters. If algal mats form, harvest the seaweed and dispose of it (or compost it) away from the grow-out site. Bag flipping serves to expose fouling organisms to the sun which effectively bakes them off. Regular bag flipping keeps fouling minimized on both sides of the bag.

6.5 Biofouling/ Pests

6.5.1 Sea Squirts/ tunicates/ hydroids

Fouling organisms found with oyster growing gear which may contribute to clogging the oyster growing devices and interfering with the ability of the oysters to maximize feeding. Brush off growing gear of fouling like sea squirts, tunicates and hydroids. Regular bag flipping keeps fouling at bay.

6.5.2 Mud Blisters

Mud Blisters are caused by worms in the mud that get incorporated into the oyster shell and make the oyster less marketable. Not only is it unsightly, but mud blisters may make the meat of the oyster muddy should a shucker pierce the mud blister on the inside of the oyster shell. Mud blisters are avoided by not growing oysters in the mud.

6.5.3 Boring Sponge

Affecting the integrity of the shell, not the oyster meat itself, the boring sponge penetrates an oyster shell and makes the shell too brittle to open without shattering the shell. With a brittle shell, it is not likely to open an oyster without getting shell fragments in the meat and makes it undesirable for shucking. It is evidenced by tiny holes in the shell once the sponge is rubbed or brushed off. It can be treated with air drying or brine dipping (with air drying), to kill the sponge without killing the oyster. Treating juvenile oysters this way can put the oyster at risk.

6.6 Storm Damage

Threats to a farm by storm can be devastating. With news of an impending hurricane or strong winds, extra anchors on the support structure may help "weather the storm". If a very serious hurricane is expected to hit, a decision could be made to retrieve all floating gear with the shellfish in it and store out of water for one-two day duration (a very long low tide) to preserve the crop from storm damage, keeping the oysters cool and hydrated. This, of course, would have to be done with the Shellfish Constable's knowledge and support. After the storm passes, the crop would have to be re-deployed.

Another strategy for protecting the crop from storm damage would be to employ the deep-water storage system to protect the floating gear from being thrashed around. There is concern for dissolved oxygen levels, though, especially in the summer months, when dissolved oxygen levels are typically at their lowest. Dissolved oxygen levels in the deep-water site could be tested periodically in the summer to have a course of action planned out in case of a hurricane.

The winter sinking of the crop in the deeper part of Lonnie's Pond appeared to be a successful strategy for overwintering the crop and protecting it from ice damage. It is a safe strategy that can be utilized if the deep-water space is available. From the experience last winter, the crops appeared to come through the icy part of the year in good shape and should be a good course of action should it successfully overwinter the crop again in the winter of 2017 and 2018.

6.7 Theft

Threats by theft can be very discouraging. Surveillance cameras can be set up and monitored by several outlets, especially with the Town if the aquaculture project has a municipal component to it. The Town of Barnstable has cameras set up to monitor some of the municipal shellfish growing areas. It would be advised that more than one camera be deployed to not only get the thieves in action, but also capture the numbers on license plates of the trailers and/or trucks used.

Another theft "alarm" is vigilance by neighbors living around the aquaculture site. If the neighbors are coached in what to do should they see trouble with the site, they might feel engaged to see that the project is successful. Phone numbers with 24-hour response (Police Department) could be shared as long as there are willing participants. Neighbors who serve on the watch might be proud to participate and may be able to be "paid" in oysters for their service if it was legally and procedurally found to be compatible with the project.

7.0 Water Quality Monitoring and Results

7.1 Water Quality Monitoring Methodology

SMAST staff monitored the Lonnie's Pond demonstration over the 2016 growing season. A sampling program was implemented to establish both a 2016 water quality benchmark for Lonnie's Pond, as well as to initially quantify nitrogen removal due to denitrification enhancement attributable to the oyster installation. From June 29, 2016 to October 19, 2016, eight sampling stations were monitored to further refine the long term water quality sampling database that was initiated for Lonnie's Pond as part of the MEP (Howes et al. 2006).Sampling occurred every other week during mid-ebb tide at the surface, bottom, and at mid-water column, if possible. During the demonstration period, intensive water column sampling also occurred over complete tidal cycles on August 10, 2016, August 24, 2016, September 13, 2016, and October 12, 2016. Samples were collected at nominal hourly intervals over consecutive flooding and ebbing tides.

An Acoustic Doppler Current Profiler (ADCP) was deployed to measure current direction through the oyster area relative to the sampling points in order to quantify changes in water column constituents through the oyster field. Particulate organic nitrogen (PON), total chlorophyll-*a*, bioactive N, orthophosphate, dissolved oxygen, and the complete suite of nitrogen components were assessed. The constituents of total nitrogen include (nitrate + nitrite), ammonia, dissolved organic nitrogen (DON) and PON. Samples were analyzed for: temperature, salinity, total nitrogen (TN), chlorophyll-*a* (Chl-*a*), pheophytin-*a*, orthophosphate, dissolved oxygen (DO), transparency (secchi depth), and alkalinity according to protocols outlined for the MEP.

Quality assurance samples (field duplicates) were also collected, as is protocol according to the Quality Assurance Project Plan (QAPP) under which SMAST collects MEP samples. DO and temperature profiles were performed at multiple depths and Winkler samples were collected in triplicate at water quality stations that had in-situ sensors. Continuous water quality monitoring of DO and Chl-*a* was conducted using five YSI-6600 sondes and HOBO® light sensors anchored at stations M5, M6, M7 and M8. Samples were also collected at the outflow from the cranberry bog and herring run when sufficient flow was available.

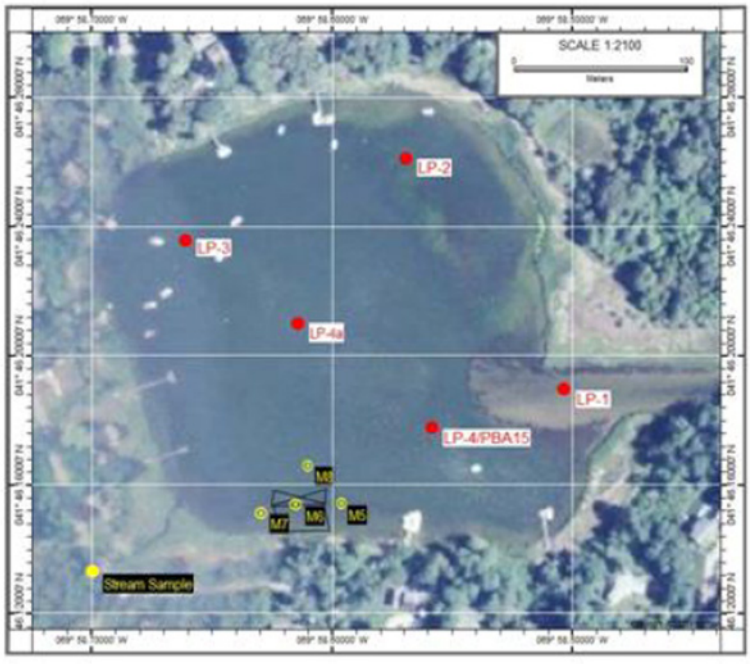


Figure 7-1 - SMAST Water Quality Monitoring Stations

7.2 Major Results of 2016 Water Quality Monitoring

A summary of key results from the SMAST Water Quality monitoring in year one follows.

- **Phytoplankton biomass was removed by the oysters as water flowed through the oyster deployment.** This is evidenced by the reduction in Chl-*a* concentrations and PON within the oyster field, relative to samples taken adjacent to the installation. These reductions in Chl-*a* and PON are statistically significant ($p<0.5$) and were seen during the tidal studies designed to capture water ebbing through the demonstration area;
- **Bioactive N levels declined by 12 to 20 percent during passage through the oyster field.** The decrease in bioactive nitrogen concentrations is likely due to the lowering of PON concentrations;
- **Observed nitrogen removals are conservative estimates** due to the oblique patterns of flow through the oyster area in the surveys, which underestimates uptake;
- **There was a clear temporal trend with higher levels of PON, Chl-a and bioactive N in mid-summer**, which is consistent with increased eutrophic conditions in estuaries in warmer summer months (poorest water quality July through mid-September);
- **Because of drought conditions, the oyster study was not influenced by surface water flows in 2016.** The nitrogen loading to Lonnie's Pond from Pilgrim Lake calculated during the low flow conditions of 2016 was significantly lower than was calculated for 2003 flows; and
- **The SMAST findings suggest that oyster growth will not be food-limited in Lonnie's Pond.** Food concentrations for summer and fall were 1,740 (±213) and 633 (±57.8) µg C/L seawater, respectively. Observations by others suggest that there is no increase in oyster feeding rates at food concentrations above 300 µg C/L (Tenore and Dunstan 1973). During the second and third years of the demonstration program, water flow to maintain adequate food concentration will be assessed throughout the field.

8.0 TMDL Compliance

Y1 of the demonstration monitoring project in Lonnie's Pond showed favorable results achieving nitrogen reduction. The results from year one of the project indicate that it is possible to use oysters to meet TMDL requirement and total nitrogen reduction targets. The oysters removed sufficient nitrogen through uptake alone. Mortality was low and the bag and line system and overwintering installation provided sufficient protection from predation and supported strong oyster growth. Y2 and Y3 of the Demonstration Project in Lonnie's Pond will provide additional data to evaluate the effectiveness of this non-traditional technology.

Overall, it appears that denitrification conservatively removes approximately 0.67 kg N for each 1 kg N removed in oyster harvest. In September/October when oysters had reached their mid-season biomass increase, an amount equivalent to almost one-third of the biodeposition rate was denitrified each day. The sediment incorporated biodeposits continue to continue to enhance denitrification after oyster harvest and will likely continue into the next spring and summer increasing the estimated N removal.

As further discussed in Section 9.0, either Y1 or Y2 oysters can be used to meet both TMDL requirements and total nitrogen load reduction targets. MassDEP is not validating results of denitrification enhancement at this time. Therefore, Full-Scale Implementation scenarios outlined in Section 9.0 focus on direct removal of nitrogen by uptake. However, is anticipated that the denitrification enhancement will be proportional to the amount of biodeposition, based on the 2016 SMAST Technical Report (Howes et. al, January 2017). If additional removal of nitrogen by denitrification is eventually demonstrated to the satisfaction of MassDEP, this removal would provide an additional margin of safety for regulatory compliance, beyond the removal predictions outlined in Section 9.0. Additional information regarding denitrification monitoring and modeling predictions is included in both the 2016 SMAST report and the Year 1 Lonnie's Pond Technical Memorandum dated October, 2017.

9.0 Full-Scale Aquaculture Scenarios

This section discusses what full-scale implementation at Lonnie's Pond would entail, based on data collected to date, TMDL scenario goal identified by MassDEP for Lonnie's Pond, estimated cost based on costs to date, and considerations regarding the feasibility of engaging commercial growers to assume responsibility for the Lonnie's Pond operation once MassDEP approves the removal data. This section also discusses anticipated permitting requirements for full-scale implementation at Lonnie's Pond as well as considerations regarding additional public engagement and future Town Staffing needs.

9.1 Scenarios and Cost

The MEP nitrogen reduction goal for Lonnie's Pond is approximately 660 pounds per year (300 kg/yr). The potential annual nitrogen per acre per year in Lonnie's was calculated based on the nitrogen content of oysters, densities, and weights measured in the Lonnie's Pond during Year 1 of the Demonstration Project. Based on these values, six different scenarios were developed identifying the number of Y1 and Y2 oysters and pond area needed to meet the full MEP removal goal as well as portions of the goal. It should be noted that the scenarios presented in Table 9-1 should be considered preliminary at this time, as they are based on one year of data collection, and will be further confirmed and refined based on data collected in Y2 and Y3 of the Demonstration project. The scenarios are summarized in illustrated in Figure 9-1 and described in Table 9-1, which summarizes oyster numbers and sizes, densities, pond area, number of bags, and other parameters associated with each potential scenario. Approximate costs for each of the scenarios are also detailed in Table 9-1. Table 9-2 provides assumptions used when developing these costs. The assumptions in Table 9-2 are subject to review and revision; therefore the costs in Table 9-1 are not necessarily final budgetary numbers, but do provide a comparative cost for each scenario.

9.2 Transition to Commercial Growers

The comparative cost numbers in Table 9-1 illustrate that a Full-Scale Implementation program at Lonnie's Pond could potentially be profitable for a commercial grower, and is likely more cost efficient for the Town than municipal operation of the aquaculture program on a long-term basis. Furthermore, results from the first two years of the Demonstration Program showed that the techniques used in Lonnie's Pond to date have resulted in high quality oysters with good market value. In 2016, approximately 80 percent of the Y1 reached harvestable size (76 mm / 3 in) in one shortened growing season (the typical season begins in May), and all of the Y2 oysters had reached petite or full market size by the end of their second growing season.

From discussions with wholesalers, it is believed that the Y1 oysters will have a significantly higher market value if they are overwintered, and it is expected that many of them would be market-ready within the first few weeks of the following season.

Operation of aquaculture at Lonnie's Pond could occur under a special grant category that would include reporting and compliance measures required by MassDEP, which are yet to be determined. A benefit of transitioning the program to a commercial grower would be that once the oysters reach harvestable size, the grower could sell the oysters for a profit, whereas the Town cannot sell shellfish under its municipal propagation permit, except to another town. Some considerations regarding the potential for transitioning the program to a commercial grower are outlined below:

- The aquaculture regulations may need to be modified to allow a new grant category for this operation, which specific reporting and compliance requirements as well as requirements for growing the oysters in floating gear at specified densities;
- The Town may want to consider issuing a Request for Proposals for the project, to allow multiple private growers as well as potentially licensed hatcheries to express their interest and approach to the project;

- It is expected that MassDEP approval of aquaculture in Lonnie's Pond as a means of nitrogen removal and TMDL compliance would be contingent upon using the same floating bag methodologies and oyster densities as have been implemented to date. If any options for alternative types of floating gear would need to be investigated with MassDEP and would need to be specified in the grant license; and
- The requirement to avoid sediment disturbance may be unrealistic, but also unnecessary if the nitrogen removed via the denitrification pathway is discounted.

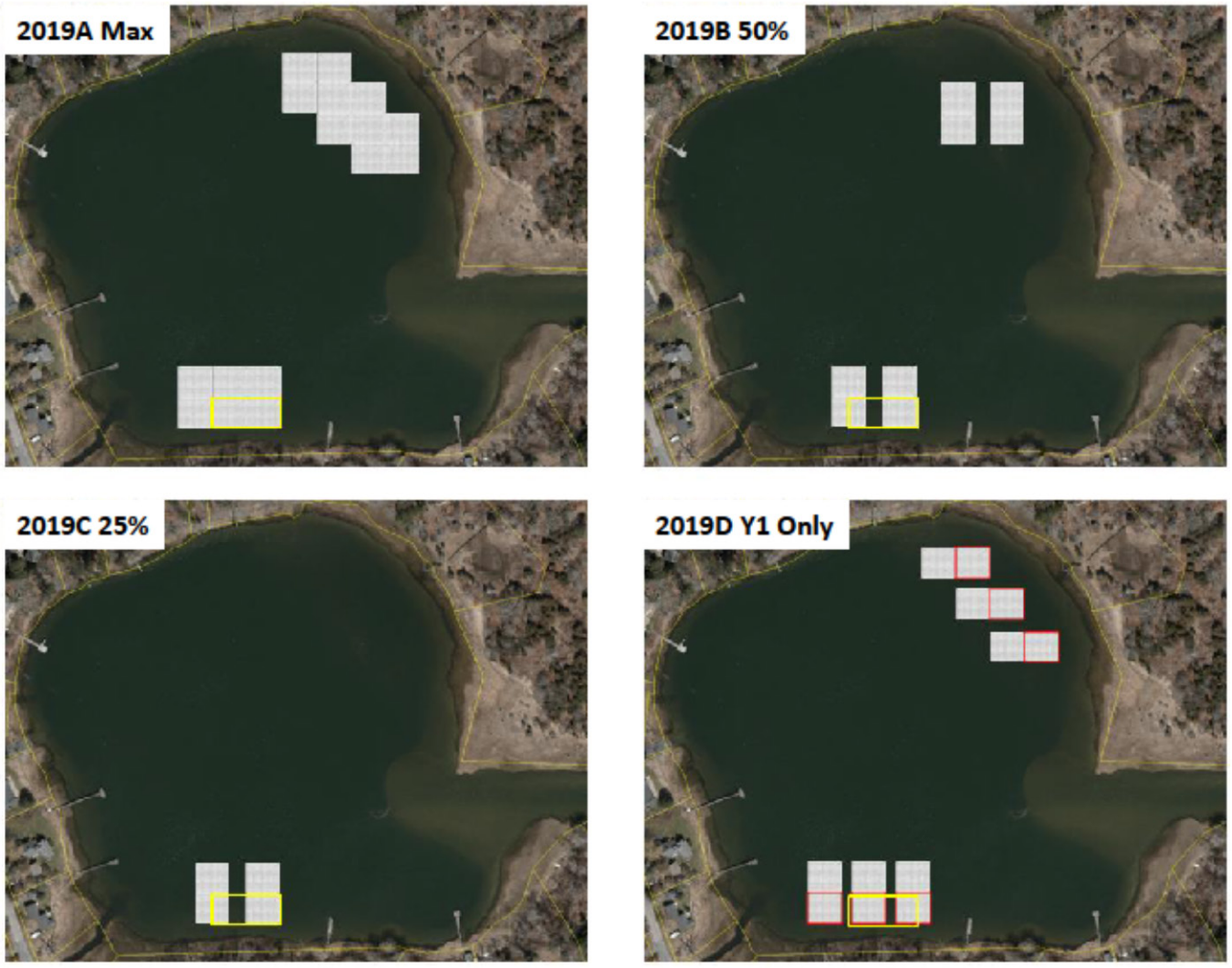


Figure 9-1 - Full Scale Implementation Scenarios

Table 9-1 - Full Scale Implementation Costs

	2019A	2019B	2019C	2019D	Town 2019B	Town 2019C
	Max Coverage	50% MEP	25% MEP	Y1 Only	50% MEP	25% MEP
Y1 Bags	1,650	843	422	6,280	843	422
Y2 Bags	6,600	3,372	1,688		3,372	1,688
Total Bags	8,250	4,215	2,110	6,280	4,215	2,110
Area Utilized	1.5	0.78	0.38	1.2	0.78	0.38
Y1 Oysters Started	1,740,000	888,000	445,000	6,610,000	888,000	445,000
Y2 Oysters Started	1,650,000	843,000	422,000	-	843,000	422,000
Live Oysters Extracted	1,530,000	784,000	392,000	6,280,000	784,000	392,000
Sale Price of Program Oysters	$ 0.35	$ 0.35	$ 0.350	$ 0.120	$ -	$ -
Total Market Value of Program Oysters	$ 535,500	$ 274,400	$ 137,200	$ 715,920	$ -	$ -
Total Capital for Floating Gear	$ 86,209	$ 25,444	$ -	$ 100,591	$ 25,444	$ -
Labor for Fabrication of Floating Gear	$ 71,625	$ 21,188	$ -	$ 47,000	$ 15,255	$ -
Over-winter Gear (Fab Labor & Materials)	$ 13,281	$ 672	$ -	$ 85,625	$ 604	$ -
Capital for Other Equipment	$ 95,375	$ 80,475	$ 62,175	$ 46,975	$ 7,800	$ 7,800
Y1 Capital Requirement	$ 266,490	$ 127,778	$ 62,175	$ 280,191	$ 49,103	$ 7,800
Amortized Financed Gear Cost	$ 64,841	$ 31,090	$ 15,128	$ 68,175	$ 9,821	$ 1,560
Seed Cost	$ 55,680	$ 28,416	$ 14,240	$ 211,520	$ 28,416	$ 14,240
Field Labor Cost	$ 278,063	$ 153,881	$ 76,488	$ 262,319	$ 110,795	$ 55,071
Business Overhead / Administration	$ 76,854	$ 49,546	$ 40,813	$ 100,863	$ 9,300	$ 9,300
Total Annual Expenses	$ 475,438	$ 262,933	$ 146,668	$ 642,876	$ 158,331	$ 80,171
Program Oversight	$ 3,360	$ 3,360	$ 3,360	$ 3,360	$ 3,360	$ 3,360
Town Net Cost	$ 3,360	$ 3,360	$ 3,360	$ 3,360	$ 158,331	$ 80,171
Grower Net Profit	$ 60,062	$ 11,467	$ (9,468)	$ 73,044		
Net Profit % of Gross Revenue	11%	4%	-6.9%	10.2%		
N Removed by Uptake, kg	290	148	74	297	148	74
N Removed in Shells (Mortality), kg	3	2	1	2	2	1
Annual N Removal, All Pathways, kg	293	150	75	298	150	75
% of MEP Annual Removal Target	99%	51%	25%	100%	51%	25%
Ongoing Labor Requirement (hrs/yr)	8,165	4,604	2,540	8,995	4,404	2,340
Labor Full Time Equivalents	4.1	2.3	1.3	4.5	2.2	1.2
Town $/kg of Target N Removed	$ 11	$ 22	$ 45	$ 11	$ 1,055	$ 1,069

Table 9-2 - Full Scale Implementation Assumptions

	2019A	2019B	2019C	2019D	Town 2019B	Town 2019C
	Max Coverage	50% MEP	25% MEP	Y1 Only	50% MEP	25% MEP
Number of new spat bags	400	116	0	2,023	116	0
Spat bag cost	$ 10,000	$ 2,900	$ -	$ 50,583	$ 2,900	$ -
Floating bags material cost	$ 76,209	$ 22,544	$ -	$ 50,008	$ 22,544	$ -
Floating bags fab labor cost	$ 71,625	$ 21,188	$ -	$ 47,000	$ 15,255	$ -
New Winter racks	43	2	0	274	2	0
Winter rack cost	$ 8,500	$ 430	$ -	$ 54,800	$ 430	$ -
Winter rack labor	$ 4,781	$ 242	$ -	$ 30,825	$ 174	$ -
Initial Deployment Labor	$ 81,094	$ 40,603	$ 19,781	$ 77,844	$ 29,234	$ 14,243
Recondition winter bags labor	$ 6,188	$ 15,806	$ 7,913	$ 23,550	$ 11,381	$ 5,697
Split Labor	$ 10,313	$ 5,269	$ 2,638	$ 39,250	$ 3,794	$ 1,899
Flip Labor	$ 30,938	$ 15,806	$ 7,913	$ 23,550	$ 11,381	$ 5,697
Remove Gear Labor	$ 51,563	$ 26,344	$ 13,188	$ 39,250	$ 18,968	$ 9,495
Y1 Winter Labor	$ 15,469	$ 7,903	$ 3,956	$ 58,875	$ 5,690	$ 2,849
Y2 to Market Labor	$ 82,500	$ 42,150	$ 21,100	$ -	$ 30,348	$ 15,192
Storage racks	107	35	0	0	35	0
Storage rack materials	$ 10,667	$ 3,493	$ -	$ -	$ 3,493	$ -
Storage rack labor	$ 6,000	$ 1,965	$ -	$ -	$ 1,415	$ -
Storage rack sq.ft.	2,667	873	0	0	873	0
Other space sq.ft.	500	500	500	500	500	500
Space rental	$ 32,667	$ 14,733	$ 6,000	$ 6,000		
Administrative hours	750	500	500	2,000	300	300
Administrative labor	$ 28,125	$ 18,750	$ 18,750	$ 75,000	$ 8,100	$ 8,100
NAP Coverage	$ 6,563	$ 6,563	$ 6,563	$ 6,563		
Disease testing				$ 4,800	$ 1,200	$ 1,200
Business insurance	$ 2,500	$ 2,500	$ 2,500	$ 2,500		
Business misc	$ 3,000	$ 3,000	$ 3,000	$ 2,000		
Equipment insurance	$ 4,000	$ 4,000	$ 4,000	$ 4,000		
Equipment delivery costs	$ 500	$ 500	$ 2,000	$ 2,000		
Carolina Skiff 19DX	$ 9,620	$ 9,620	$ 9,620	$ 9,620		
Yamaha F90LA	$ 10,405	$ 10,405	$ 10,405	$ 10,405		
Boat Trailer	$ 2,650	$ 2,650	$ 2,650	$ 2,650		
Winter raft	$ 2,800	$ 2,800		$ 2,800	$ 2,800	$ 2,800
Field maintenance craft	$ 3,000	$ 3,000	$ 3,000	$ 3,000	$ 3,000	$ 3,000
Field float	$ 12,000	$ 12,000		$ 12,000		
Chevy 4500 Reefer	$ 49,900					
Truck with coolers		$ 35,000	$ 30,000			
Utility trailer	$ 2,500	$ 2,500	$ 2,500	$ 2,500		
Totes, tools	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000

Shell N% of DW	2.00%
Meat N% of live wt	10.50%
MEP Target kg N	297
Materials cost per bag	$ 13.30
Cost of spat bag for 2-3mm seed	$ 25.00
Years of service for Gear & Equipment	5
Commercial cost of capital, 5 yr @ 8%	21.7%
Winter bags/rack	20
Materials/rack	$ 200
Storage materials/rack	$ 100
Storage bags/rack	45
sq.ft. per storage rack	25
Winter racks available	40
Floating spat bags available after Y3	180
Bags available after Y3	2,520
Storage rental	$ 10.00
Office rental	$ 12.00
Inspections per season	6
Hours per inspection	8
Report hrs	16

	Y1	Y2
Mortality	5%	7%
Seed cost/1,000 oysters	$ 32	
Target Seed/bag	3,000	
Target Oysters/bag	1000	250
Denitrification factor (% of uptake)	68%	68%
Average Weight at Death (DW g/Oyster)	0.250	1.20
Deployment Weight (DW g/Oyster)	0.010	0.46
Ending Weight (DW g/Oyster)	0.46	1.78

	Base	Loaded
Town Labor Rate	$ 18.00	$ 27.00
Program Oversight Labor	$ 35.00	$ 52.50
Grower Labor Rate	$ 25.00	$ 37.50

9.3 Financing

Additional discussion and investigation is needed in regard to funding mechanisms for the overall wastewater management project, including the Aquaculture Non-Traditional Technology. Potential funding/financing options include: State Revolving Fund (SRF) loans, MassDEP 604b/319 grants, USDA rural development grants, 5 Star Wetland and Urban Waters Restoration grants, MA CZM Coastal Pollutant Remediation (CPR) Grant Program, North American Wetlands Conservation Act grants, and Massachusetts Environmental Trust (MET) General grants. Availability of these funding sources would be dependent on a successful application process, and can be further investigated if the Town elects to pursue these funding sources. Permitting.

9.4 Permitting

Depending on the scenario selected, permitting requirements are anticipated to include a Notice of Intent (NOI) or Request for Determination of Applicability as well as a Section 404 Permit approval from the US Army Corps of Engineers. If more than 10 percent of the pond area is utilized for aquaculture, it is likely that an NOI rather than an RDA would be required by the Conservation Commission, and that a Pre-Construction Notification (PCN) application would be required by the US Army Corps of Engineers rather than the project qualifying under the Self-Verification Process.

9.5 Communication Plan

For a full scale implementation at Lonnie's Pond, additional public outreach and engagement is recommended. This could take the form of either a public meeting at the Town Hall where the plan is presented and comments are solicited; posting the draft Lonnie's Pond management Plan on line and solicitation of written comments; or hosting a public visitation day at Lonnie's Pond; or a combination of any of the above.

9.6 Town Staffing

If the Town were to operate the Lonnie's pond full-scale aquaculture themselves, it is anticipated that additional season staff would be needed to for the installation and breakdown of the floating gear fields each year, as well as the ongoing splitting of the Y1 seed and redistribution into larger bags, as well as potentially relocating Y1 oysters into floating year or a bottom setting each winter. In addition, harvesting and associated reporting would be an additional task for town staff. It is likely that this additional field and reporting workload would require hiring one or two additional seasonal, or potentially permanent, year round staff.

10.0 Full Scale Implementation Management Plan

The next steps in the aquaculture include coordination with MassDEP to gain consensus regarding the implications of the Demonstration Project for full-scale aquaculture implementation and to determine the regulatory treatment of non-traditional technologies as a major component of the Town's efforts to meet TMDL requirements and its strategy to manage wastewater. At the conclusion of Y3 of the Demonstration Project in December, 2018, data from the three required years of deployment should be compiled and submitted to MassDEP for review, and a meeting should be held to discuss next steps required for MassDEP approval of aquaculture as a part of a long-term TMDL compliance program. Similarly, at this time, the town can review the final results of the three-year Demonstration Project to consider, select, and propose to MassDEP their selected scenario for Full-Scale implementation at Lonnie's Pond.

10.1 Watershed Permitting

MassDEP is in the process of developing guidance for a Watershed Permit that would include non-traditional technologies. This new wastewater management and impact mitigation permitting program would provide for a watershed-based approach to restore embayment water quality on Cape Cod. It is anticipated that enrollment in the program will demonstrate that the Town is taking action to address wastewater. The Pleasant Bay Alliance (PBA) has been meeting with the Cape Cod Commission and MassDEP to discuss the guidance to identify regulatory issues that would

fall under a watershed permit for the Pleasant Bay watershed, potentially including Lonnie's Pond. It is anticipated that the Watershed Permit process will likely require that the Town submit a Watershed Permit Plan that:

- Identifies proposed technologies and approaches in the proposed watershed or subwatershed;
- Describes the adaptive management strategy or process for making implementation decisions;
- Specifies a monitoring plan and describe the contingency plan;
- Identifies all permits and approvals that are required by local, regional, state, and federal entities.

Further discussion with MassDEP and the PBA is necessary once it is determined that MassDEP will accept aquaculture as part of a TMDL compliance program and the Town selects their preferred scenario for implementation.

10.2 Oyster Configuration

Oyster configuration for Full-Scale Implementation will be determined once a scenario is selected. Section 9 describes the potential scenarios under consideration. This section can be updated to identify the number of oysters, size, bag layouts, multi-year planning once a scenario is selected for implementation. For planning purposes, a safety factor of approximately 15 to 20 percent is proposed in regard to number of oysters to be installed, in case an adverse event results in oyster loss. In addition, pending the results of the denitrification studies, denitrification may provide an additional margin of safety in terms of nitrogen removal for TMDL compliance.

10.3 Required Tasks and Schedule of Activities

The schedule will be determined once a scenario is selected. Section 9 describes the potential scenarios under consideration. An initial outline of required tasks and associated schedule dates is provided below:

- Compile and provide Demonstration Project results to MassDEP – spring, 2019;
- Select preferred Full Scale Implementation Schedule – spring, 2018;
- Meet with MassDEP to discuss – spring, 2019;
- Determine number and size classes of oysters needed, as well as equipment needs – TBD; and
- Develop RFP if commercial route is chosen – TBD.

10.4 Overwintering Protocols

These are described in Section 3.1 and briefly repeated here. Typically oysters are kept on the surface as late into the winter season as possible, depending on environmental conditions including temperature and dissolve oxygen. As a guide, oysters should be submerges below the surface as soon as the water temperature drops below 6°C for six days in a row, although if water temperature and observations suggest that the water will freeze imminently, it is prudent to submerge oysters in advance of this trigger. In the spring, oysters should be raised once water temperatures reach 6°C for six days in a row.

10.5 Long-Term Costs

Long-Term cost can be determined once a scenario is selected for implementation. This section can be updated at that time.

10.6 Excess Oyster Disposal

This will be determined once a scenario is selected. Options for disposal include harvesting full size oysters or trading to Falmouth, MA for quahogs (if Town run), or sale of intermediate seed, market size oysters or both, if grower run.

10.7 Catastrophic Loss and/or Project Abandonment

If there is a catastrophic loss for one year, then either the safety factor from previous years will account for this, or nitrogen removal will need to be made up in subsequent years. Any issues will be reported to MassDEP, and it is expected that discussion with them would be needed to reach resolution. If multiple years of the project showed less than expected nitrogen removal, it would be necessary to consider replacement of the aquaculture with alternative types of treatment, such as PRBs or conventional sewering.

Appendix A

Boston University Stable Isotope Laboratory QAQC

and

Science Wares SOPs

BOSTON UNIVERSITY
STABLE ISOTOPE LABORATORY

Robert Michener, Laboratory Manager
Department of Biology, 5 Cummington Street
Boston, MA 02215
Tel. 617-353-6980, Fax: 617-353-6340 email: michener@bu.edu

Quality Assurance and Quality Control

Instrumentation for stable isotope analysis has expanded to include both the original Finnigan Delta-S and now two GV Instruments IsoPrime isotope ratio mass spectrometer. With the addition of the GVI instruments and associated peripherals, we have automated stable isotope analysis of most organic (and some inorganic) samples for carbon-13 and nitrogen-15. The workhorse of continuous flow measurements of solid samples for carbon and nitrogen isotopes is done by the GVI IsoPrime and a Eurovector elemental analyzer, combined with a diluter and reference gas box.



Samples for automated isotope analysis are first weighed out into tin boats to the nearest 0.01 mg on a Mettler AE240 or a Sartorious micro electronic balance. During a sequence run by the mass spectrometer, each sample is flash combusted at 1800ºC in the Eurovector CN analyzer; the combustion products (CO_2, N_2 and H_2O) are separated chromatographically and introduced into the mass spectrometer, with water removed in a chemical trap. The gases of interest are then introduced into the mass spectrometer for isotope analysis and the rest pumped away. The sample isotope ratio is compared to a secondary gas standard, whose isotope ratio has been calibrated to international standards. For $^{13}C_{V\text{-}PDB}$ the gas was calibrated against NBS 20 (Solenhofen Limestone), NBS 21 (Spectrographic Graphite), and NBS 22 (Hydrocarbon Oil); for $^{15}N_{air}$ the gas was calibrated against atmospheric N_2 and IAEA standards N-1, N-2, and N-3 (all are ammonium sulfate standards). All international standards were obtained from the National Bureau of Standards in Gaithersburg, MD.

International standards used for water samples include V-SMOW, GISP and SLAP, which were utilized to calibrate the secondary gas standard. In the past, water samples were prepared using the guanidine hydrochloride technique for oxygen-18 and the zinc reduction technique for deuterium (zinc obtained from John Hayes, Indiana University). With the addition of the GVI MultiFlow and ChromeHD systems, we are now able to automate both procedures. Oxygen-18 analysis is done via CO_2 equilibration and deuterium analysis is done via pyrolysis in the ChromeHD system.

When running gas samples on the Finnigan Delta-S, as a daily check on instrument performance we run a second gas (lecture N_2 or CO_2) that is isotopically distinct from our standard gas. If the isotope values are within 0.05 per mil of its long-term record, analysis proceeds; otherwise, further analysis stops until any problems are resolved. Internal precision for the instrument is $\pm$0.014 per mil. For solid continuous flow samples, a suite of in-house standards are first analyzed. If they fall within laboratory specifications, client sample analysis then proceeds.

Required external precision of a sample (i.e. replicate analysis) for either ^{15}N or ^{13}C is 0.2 per mil. Typically, our precision is better than 0.1 per mil for well-ground organic tissue samples using the trapping box.

Samples run in continuous flow mode are currently within 0.2 per mil for both nitrogen and carbon. In addition to carbon and nitrogen isotopes from the same sample, continuous flow will also report %C and %N data.

The lab runs one replicate per 10 samples, and any anomalous results are rerun. As a check on the combustion and cryogenic distillation steps, a laboratory standard is run every 15 samples. This standard is either peptone, a hydrolyzed animal protein from Sigma Chemical Company, glycine, or citrus leaves, SRM 1572. Both have been well documented by several stable isotope laboratories and their isotopic values are well known. Its value must be within 0.15 per mil of its documented value. If it does not, the samples preceding the standard are considered suspect and rerun.

The addition of the GVI Instrumentation precision of water samples (oxygen-18 and deuterium) has improved significantly and is extremely good. The lab generally runs duplicates of all samples for oxygen-18 if there is enough water. The precision is usually 0.1 permil or better. An internal lab standard is run after every 4 client samples as a check on the instrumentation. Deuterium samples are run with the ChromeHD pyrolysis system. Three injections are done with each sample, with the first injection discarded, due to memory effects in the system. The standard is Boston University deionized water, collected in batch fashion and stored. The water standard is within 0.2 per mil of its long-term value for deuterium and 0.2 per mil for oxygen-18. In addition, the metabolic samples are inputted to a spreadsheet that calculates FMR (Field Metabolic Rates). If calculated values are not within acceptable ranges, the suspect samples are rerun. The calculations are based on the equations of Lifson and McClintock (1966), as modified by Kenneth Nagy, UCLA.

For carbonate samples, NBS-20 and Carera-Z are used as two point calibration standards. Precision is currently 0.05 permil for carbon-18 and 0.06 permil for oxygen-18. CO_2 air and breath samples are calibrated using atmospheric air and a 1% CO_2/helium mix gas. The mix gas was checked against calibration gases obtained from Oztech Corporation, Texas.

Data is presented in a tabular form and can be sent by fax, mail or email. The sheet includes sample ID, mass/volume used, isotopic value and % organics (if applicable). All isotopic data are rounded to 2 decimal places.

We request that a sample list be included with all samples and that all samples be clearly identified. This allows the Laboratory Manager to look over the data and compare the isotope values against generally accepted values for that type of sample. Any samples that appear anomalous are rerun if possible to check their values; if preloaded, they are flagged as anomalous for the client.

Percent organics and nitrogen protocol

Samples are weighed out to 0.001 mg into tin capsules on a Sartorius XM1000P microbalance. They are combusted in a Fisons NA1500 elemental analyzer and measured using Eager200 software. Check standards are inserted into the run to ensure precision and quality control. Any anomalous samples are reweighed and rerun. Precision for replicate samples is 0.2 percent for carbon, and 0.5 percent for nitrogen, but will vary depending on the heterogeneity of the material.

The elemental analyzer is recalibrated each day using a size series of 5 acetanilide standards ranging from 2 to 0.2 mg. A sixth acetanilide is then measured to check for accuracy.

Samples can be either dried and ground by the client, or shipped to the laboratory in dried or wet form and ground by the lab. A mortar and pestle and liquid nitrogen are used to ensure a well-ground, homogenous mix. Samples can be stored in any container, but preferably in scintillation vials or Eppendorf tubes.

If samples are to be prepared by the client, they should be placed in 96 well trays, leaving slots 6 and 12 open for BUSIL internal standards. The amount of material will vary, but should be around 1, 2, and 5 mg for animal tissue, plant tissue, and soils, respectively. The spreadsheet found on the BUSIL website (http://www.bu.edu/sil/PDF%20files/BUSIL%20EA%20Sample%20Submission.xls) should be filled out and sent electronically to the laboratory manager prior to shipping.

The results are put into an Excel spreadsheet and sent to the client, reporting sample ID's, masses, and percent carbon and nitrogen.

Maintenance on the elemental analyzer is performed after a run of 120 samples. Excess tin and ash are removed from the combustion column. The reduction column is changed after 300 to 500 sample analyses. The combustion column is replaced after 1,500 samples.

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ATTACHMENT K

TECHNICAL MEMORANDUM – SITE CHARACTERIZATION AND EVALUATION FOR PERMEABLE REACTIVE BARRIERS

AECOM
9 Jonathan Bourne Drive
Pocasset, MA 02559
www.aecom.com

508.833.6950 tel
508.833.6951 fax

Memorandum

To	George Meservey, Director of Planning & Community Development Michael Domenica, PE, Program Manager
CC	Betsy Shreve, AICP, AECOM Project Director Paul Dombrowski, AECOM Mark Owen, AECOM Juli Marrion, AECOM James Begley, MT Environmental Restoration
Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 3 – NT Demonstration Projects** **Deliverable 3.c.5 - Final Technical Memorandum on Site Characterization and Evaluation for Permeable Reactive Barriers (evaluation criteria and ranking)**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	May 19, 2016

1. Background

This Technical Memorandum documents the process used to select locations for Permeable Reactive Barrier (PRB) Demonstration Testing. An objective assessment of potential locations, including use of a system to record rankings of sites based on established criteria, formed the basis for selection. The selected locations will be used to develop a Preliminary Engineering Work Plan, which will detail designs, schedules, and costs for PRB demonstrations. Strategies for performance verification through groundwater monitoring will be included in the Work Plan.

1) Key Terms

(1) Permeable Reactive Barrier (PRB) – consists of a zone of reactive material installed in the path of a dissolved contaminant (e.g., nitrate) plume.

(2) Denitrification – biological conversion of nitrate to inert nitrogen gas by naturally occurring bacteria.

(3) Reactive media (amendments) – material used to stimulate bacteria to transform nitrate to nitrogen gas.

(4) PRB Installation Methods

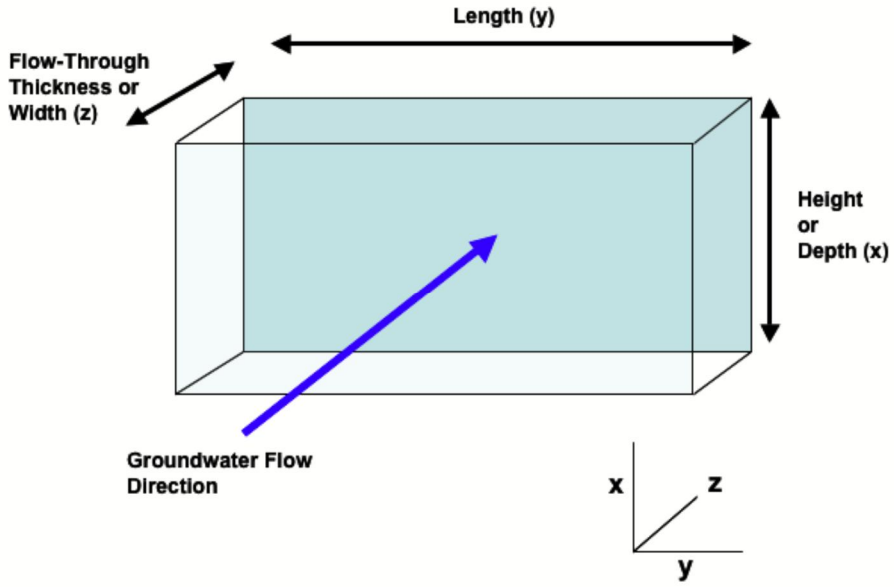
- excavating a long deep trench to place reactive solid material in the path of target groundwater,
- using soil boring and/or wells to inject a reactive liquid or emulsion in the path or target groundwater flow, and
- using soil borings and wells to place a solid reactive material in the path of target groundwater.

(5) Mass flux - a rate measurement of contaminant mass moving through a specific defined area, expressed as mass/time/area (e.g., kg/yr/m2).

(6) Mass discharge – the sum of mass flux across the plume and is therefore expressed as mass/time (e.g., kg/yr) – these are the same units used to express Total Maximum Daily Load (TMDL).

(7) Dimensions of a PRB – Length, height (depth) and flow through thickness.

(8) Hydraulic Capture Zone of the PRB – groundwater flow captured by the PRB from upgradient areas of the watershed.



From ITRC 2011

2. Introduction

AECOM is providing water quality and wastewater planning and engineering services to the Town of Orleans (the Town) to reduce excessive nitrogen discharges to the Town's ponds, estuaries and embayments. The Project represents the first to implement a "Hybrid" approach under the Cape Cod 208 Water Quality Plan, recently approved by both USEPA and MassDEP. The Project consists of conceptual and preliminary design to update the Comprehensive Wastewater Management Plan (CWMP) completed by the Town in 2011 to reflect the Consensus Plan (Water Quality Management Plan) developed by the Town in 2015. The Project goal is to minimize the proposed sewered footprint (area of Town and number of properties to be sewered) to the greatest extent possible by maximizing the use of several non-traditional technologies (Coastal Habitat Restoration, Aquaculture, Floating Constructed Wetlands, and PRBs). Figure 1 shows a version of the Consensus Plan Map (February 2015) showing anticipated locations of PRBs.

Major watersheds in the Town of Orleans include the Nauset Inlet, Pleasant Bay, Cape Cod Bay, and Atlantic Ocean watersheds. The groundwater system comprising these watersheds is part of the Monomoy Lens of the Cape Cod Aquifer (Walter et. al., 2004). Approximately 80% of the residential homes and many of the commercial businesses in Orleans are in the Nauset Inlet and Pleasant Bay watersheds (Wright-Pierce, 2010). These watersheds are characterized by numerous sub-watersheds contributing groundwater discharge to salt ponds and inlets. 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.

Removing nitrogen from groundwater can be mediated by naturally occurring denitrifying bacteria in the aquifer that gain energy from dissolved organic carbon or other food substrates and 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 nitrogen load removed by the PRB comes from water and wastewater recharged to the groundwater that contains nitrogen upgradient and within the hydraulic capture zone of the barrier.

The system is permeable because the food substrates and other amendments added do not interfere with groundwater flow, and nitrate is removed as groundwater passes through. A PRB would be most cost effective where groundwater transport of nitrogen is significant, with higher nitrate concentration and a relatively fast groundwater velocity, resulting in a high mass flux of nitrate through the treatment zone. It is this mass flux of nitrogen that contributes to nitrogen loading to downgradient surface waters and needs to be reduced.

There are several design concepts and variations for PRBs. Systems and amendments are engineered to optimize conditions for groundwater treatment within the PRB treatment zone depending on site conditions such as nitrate concentrations, groundwater chemistry, and groundwater velocity. PRB installation may be via trench excavation or soil boring. Trench systems typically utilize solid amendment media such as wood chips. Boring methods allow delivery of either liquid or solid amendments in the subsurface via direct placement or injection. There are also design concepts using soil borings to place electrodes for generation of amendments in the subsurface with electrochemical methods.

Trench installations require excavation to place the reactive substrate in the subsurface. Standard construction excavation equipment would not be capable of reaching targeted depths greater than 30 feet below grade. Nitrate plumes in the aquifer are expected to extend 30 feet or more below the water table and depth to the water table is variable from location to location. Trenching using a specialized one-pass trencher could go deeper, up to a total of approximately 40 to 50 feet below grade. The one-pass method cuts a trench with specialized large excavators that simultaneously backfill with the reactive materials through a delivery box that extends to the bottom of the trench. The trencher pulls this trench box along while a conveyor system keeps the box full of reactive material. Excavations must be located very close to or in natural resource areas adjacent to surface waters to possibly reach effective depths. Working in natural resource areas would increase permitting requirements and costs. Installation of trenches may also cause major disruption and abutter concerns may be significant. Trench systems located very close to surface water resource areas may not provide sufficient downgradient travel time for stabilization of groundwater chemistry before groundwater discharge to the surface water. Trenching options would generate a significant volume of soil that would need to be disposed of off-site and would likely also require an area for temporary stockpile staging.

An alternative approach for installation is to use soil borings for in-situ delivery of reactive materials. The most common amendments for this application are slow-release organic carbon electron donor substrates, such as food-grade emulsified soy bean oil. These soil boring PRB installations could be located upgradient away from resource areas and installed with minimal disturbance at the ground surface. The soil boring methods and emulsified soil bean oil have been commonly applied for in-situ treatment of nitrate and other groundwater contaminants at thousands of sites that have been closely monitored.

Denitrification PRB construction utilizing soil borings to place solid substrates such as elemental sulfur or for the placement of electrodes to generate amendments in the subsurface with electrochemical methods are more experimental but show promise.

PRB demonstration objectives generally include proof of performance and identifying design and operational factors that will influence cost and successful implementation and operation at full scale.

Specific objectives for a PRB demonstration include:

(1) Conducting testing representative of full scale application;

(2) Providing proof of nitrogen concentration and load reduction to extrapolate to (TMDL) reduction targets at full scale;

(3) Obtaining data for engineering evaluations and full scale cost estimates;

(4) Confirming time frame for technology performance; and

(5) Demonstrating programs for performance, compliance monitoring, and assessment of treated water quality.

3. Demonstration Site Identification Process

Potential PRB locations identified on the Consensus Plan Hybrid Map and additional locations were further 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 the following steps:

- Review of potential PRB locations developed through the Consensus Planning process;

- Review of Nauset, Pleasant Bay and Cape Cod Bay watersheds to identify potential demonstration locations that may not have been previously identified or variations on the identified locations;
- Assessment of potential PRB nitrogen reductions with the online WatershedMVP Multi-variant Planning tool developed by the Cape Cod Commission (http://www.watershedmvp.org/);
- Initial field visits to potential sites;
- Review of existing soil and/or groundwater quality data, where available;
- Discussion of potential demonstration sites with Town of Orleans officials;
- Refinement of criteria to be used in the Site Selection Matrix;
- Submission of the Site Selection Matrix to Town of Orleans for review;
- Ranking of sites based on criteria using Site Selection Matrix;
- Reviewing preferred PRB demonstration sites that resulted from the Site Selection Matrix process; and
- Recommending site locations for additional field investigation and Work Plan cost estimates.

This Technical Memorandum reports on the findings of these tasks.

It is important to note that while efforts were made to evaluate all available information regarding the geology and hydrogeology of potential PRB demonstration locations, site specific information is very limited. The local direction of groundwater flow has been assumed based on regional groundwater contours from the 1995 Cape Cod Commission Orleans Water Table Mapping Project (Cape Cod Commission, 1995). Water table elevations may vary locally resulting in deviations in local groundwater flow direction that affect the hydraulic capture zone of a PRB and the transport of treated groundwater downgradient.

Collection of limited site specific information, through investigations including the installation of groundwater monitoring wells and groundwater sampling was completed by AECOM in 2016 on selected sites. The investigations will be used to assess groundwater flow directions, groundwater chemistry, and the vertical distribution of nitrogen compounds in groundwater at key locations. Information and observations generated in these assessments will be reviewed and incorporated into this Technical Memorandum and the Preliminary Engineering Work Plan for Permeable Reactive Barriers.

4. Selected PRB Sites for Characterization and Evaluation

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

A - Main Street and Tonset Road (Main Street);

B - South Orleans Road at Tonset/Eldredge Parkway (Route 28 site);

C - Town Cove Gibson Road;

D - Namequoit Road;

E - Town Landfill;

F - Paw Wah Pond;

G - Rock Harbor Road Area; and

H - Kescayo Gansett Pond (Lonnie's Pond).

The eight locations are shown on Figure 2.

Information regarding selected potential PRB demonstration sites is provided in Section 4a. for use in assessing the locations against Site Suitability Criteria presented in Section 5. Based on the eight (8) locations identified above, thirteen (13) preliminary full scale PRB scenarios were evaluated for nitrogen reduction with WatershedMVP to assess the benefit and efficiency of various theoretical PRBs at full length. In some cases both shallow and deep groundwater treatment scenarios were considered. The WatershedMVP tool, developed by the Cape Cod Commission, evaluates nitrogen load based on land use in the watershed and was used to predict nitrogen load reductions based on hydraulic capture zone of a theoretical PRB at each site. A summary of WatershedMVP nitrogen load estimates for each scenario is included in Table 1 and Figures 3 and 4.

1) Description of Potential Sites in the Nauset watershed

The Massachusetts Estuaries Project (MEP) target nitrogen load reduction for the Nauset Harbor system is approximately 8,600 kg N/year, while the Town Cove sub-embayment target load reduction is approximately 6,700 kg N/year (Howes, et.al. 2012). PRBs may be implemented to remove a portion of these nitrogen load reduction targets.

Four potential locations were identified in the Nauset watershed with projected groundwater discharge to Town Cove including the Main Street site, the Route 28 site, the Town Landfill, and the Gibson Road site.

(1) Main Street and Tonset Road (Main Street Site)

The Main Street site is located close to Town Cove (~350 feet), and the full-scale PRB was projected to extend 2,250 feet along Main Street and Tonset Road in an area of mixed residential and commercial development. The depth to groundwater along Main Street is approximately 14 ft below ground surface (bgs), and the depth to groundwater along Tonset Road is approximately 32 ft bgs. WatershedMVP was used to estimate intercepted nitrogen load based on land use in the upgradient area. The WatershedMVP assessment calculated that the PRB would capture the nitrogen load from all upgradient areas of the watershed totaling an estimated 965 kilograms per year (kg/yr). Based on the WatershedMVP calculated output, assuming an effective nitrogen load reduction of 75%, a full-scale PRB would remove approximately 720 kg/yr or an estimated 0.32 kg/yr/ft of PRB length. This estimate did not include nitrogen in groundwater originating at the upgradient Orleans Town landfill that may add substantially to the projected nitrogen load intercepted.

(2) South Orleans Road at Tonset/Eldredge Parkway (Route 28 Site)

The Route 28 site is located approximately 1,200 feet upgradient of Main Street along Route 28 (South Orleans Road) near the intersection of South Orleans Road, Tonset Road, and Eldredge Parkway. This site is considered a variation of the Main Street site, and the results of demonstration at Route 28 could also be applied to full scale implementation at the Main Street Site. The land between these two potential PRBs includes a wooded swamp area that

may have local effects on the direction of groundwater flow that may affect the layout of a PRB demonstration on Main Street.

Site specific groundwater data is available from previous investigations. Several groundwater monitoring wells installed for a separate investigation at the Police Station have been identified. The depth to groundwater at Route 28 is approximately 30 ft. The full-scale PRB is projected to extend 900 feet along Route 28 and in an area of mixed residential and commercial development with Town facilities including the Orleans Police Station and adjacent Eldredge Park. This PRB would capture the nitrogen load from all upgradient areas of the watershed calculated with WatershedMVP to total an estimated 710 kg/yr. Based on the WatershedMVP calculation and assuming a nitrogen load reduction of 75%, the PRB would remove approximately 530 kg/yr or 0.59 kg/yr/ft of PRB. This location could potentially remove the most nitrate from the groundwater, and therefore be the most cost effective, on a per foot basis. This location is also potentially in the groundwater flow path of nitrogen originating at the upgradient Orleans Town landfill. However, this estimate does not include nitrogen sources from the landfill that may add substantially to the projected nitrate load reduction.

(3) Town Cove Gibson Road

The Gibson Road site is located on the east side of Town Cove on Gibson Road. The full-scale PRB was projected to extend 2,500 feet along Gibson Road in an area of residential development. Based on regional maps the depth to groundwater is approximately 23 ft but variable with rolling topography. The WatershedMVP model estimates that the PRB would capture the nitrogen load from all upgradient areas of the watershed totaling approximately 810 kg/yr. Based on the WatershedMVP output, assuming a nitrogen load reduction of 75%, the PRB would remove 610 kg/yr or 0.24 kg/yr/ft of PRB.

(4) Orleans Town Landfill Site

The Orleans Town Landfill site consists of approximately 20 acres located off Lots Hollow Road near the top of the Nauset watershed. Site specific groundwater data is available from previous investigations. The depth to groundwater is approximately 45 ft bgs at the lowest point of land elevation at the landfill but increases significantly downgradient as the land surface is higher. A previous review of groundwater monitoring data from monitoring wells routinely sampled at the landfill indicated significant concentrations of nitrate in groundwater downgradient of the landfill and former septage lagoons (MT Environmental Restoration, April, 2015). The nitrogen load from the landfill cannot be predicted with WatershedMVP because it uses parcel based land use and water supply data to estimate nitrogen loads in the groundwater. rather than actual groundwater data that would be required for this type of location. While insufficient data is available to estimate nitrate mass transport in groundwater from the landfill, it is likely significant. Recent groundwater data from the routine landfill monitoring well sampling program (October 2015) included the first data quantifying total nitrogen in addition to nitrate in samples from landfill monitoring wells. These data indicated significant nitrate concentrations in the shallow groundwater and relatively low nitrogen concentrations deeper in the aquifer. These data indicate a potential plume of ammonia (not directly analyzed) in the deeper groundwater that cannot be treated by denitrification without including an additional aerobic step converting the ammonia to nitrate.

2) Description of Potential Sites in the Pleasant Bay Watershed

The target nitrogen load reduction for the Pleasant Bay System is approximately 17,000 kg N/year (Howes, et.al. 2006). The Pleasant Bay system has numerous inlets and connected salt ponds, each with its own sub-watershed. Pleasant Bay has been designated An Area of Critical Environmental Concern (ACEC) under MGL ch. 21A Section 2 (7). The effect of designation as an ACEC compels the State to ensure that activities within or impacting the ACEC are carried out so as to minimize adverse effects. Locating a PRB within an ACEC would be anticipated to result in additional permitting costs and/or potentially reduce public acceptance. The Pleasant Bay ACEC extends inland to the 10-foot contour plus 100 feet.

Three potential locations were assessed in the Pleasant Bay watershed.

(1) Namequoit Road

The Namequoit Road site is located along Namequoit Road upgradient of the Namequoit River, the inlet to Areys Pond off Pleasant Bay. This location would be within the Pleasant Bay ACEC. The full-scale PRB was projected to extend 1,100 feet in an area of residential development. The depth to groundwater ranges approximately 25 to 55 ft along the proposed PRB length due to uneven topography. The PRB would capture the nitrogen load from all developed upgradient areas of the watershed with a WatershedMVP estimate of 180 kg/yr. Based on the WatershedMVP output, assuming a nitrogen load reduction of 75%, the PRB would remove approximately 130 kg/yr or 0.12 kg/yr/ft of PRB length.

(2) Paw W, ah Pond

The Paw Wah Pond site is located along Lockwood Lane, a private unpaved road upgradient of Paw Wah Pond and within the Pleasant Bay ACEC. The full-scale PRB was projected to extend 800 feet in an area of residential development. The depth to groundwater is approximately 21 ft bgs. The PRB would capture the nitrogen load from all upgradient areas of the watershed with the WatershedMVP estimate totaling approximately 110 kg/yr. Based on the WatershedMVP output, assuming a nitrogen load reduction of 75%, the PRB would remove approximately 80 kg/yr or 0.10 kg/yr/ft of PRB length.

(3) Kescayo Gansett Pond/Lonnie's Pond

The Lonnie's Pond site is located along Herring Brook Road within the Pleasant Bay ACEC. The full-scale PRB was projected to extend 1,000 feet in an area of residential development. The depth to groundwater ranges from approximately 2 to 22 ft bgs, with deepest depth to groundwater at the northern end. The PRB was projected to capture the nitrogen load from the watershed with the WatershedMVP estimate totaling 120 kg/yr. Based on the WatershedMVP output, assuming a nitrogen load reduction of 75%, the PRB would remove approximately 90 kg/yr or 0.09 kg/yr/ft of PRB length.

3) Description of Potential Sites in the Cape Cod Bay Watershed

One potential location was assessed in the Cape Cod Bay watershed. Inner Cape Cod Bay is also an ACEC with the landward extent to the 10-foot contour.

(1) Rock Harbor Road Area Site

The Rock Harbor Road Area Site location evaluated is along Captains Row, an unpaved road off Rock Harbor Road extending approximately 700 ft east to west upgradient of Rock Harbor. The location is outside the Cape Cod Bay ACEC in an area of residential development. The depth to groundwater ranges from approximately 10 to 20 ft bgs. The PRB was projected to capture approximately 180 kg/yr with WatershedMVP. Based on the WatershedMVP output, assuming a nitrogen load reduction of 75%, the PRB would remove approximately 130 kg/yr or 0.19 kg/yr/ft of PRB length.

Figures 1 and 2 provide a comparison of the estimated nitrate loads removed at each of the evaluated locations.

5. Site Suitability Criteria and Analysis

1) Site Selection Matrix

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 Site Selection Matrix includes the following criteria:

Site Suitability:

- Downgradient Water Use – Public water supply wells (PRBs locations should not be located where potable water supply wells are located nearby and downgradient)
- Topography - Significant changes in elevation may affect construction and monitoring
- Depth to Groundwater - Deeper water table increases costs and may affect feasibility
- Groundwater Nitrogen Profile - Nitrate concentrations and concentrations change with depth in groundwater -addresses feasibility
- Groundwater Flow Direction and Velocity - Necessary for orientation of PRB and assessing nitrate flux and cost effectiveness
- Ease of Access/Use of Property
- Representativeness - Transferability of lessons learned from demonstration testing/meets target conditions for a PRB

Permitting:

- Outside ACEC, Upland Areas (reduced permitting requirements for PRB placement)
- Abutter Compatibility
- Property Ownership/Road Layout (ease of access for PRB placement)
- Utility Conflicts (feasibility for PRB placement)

Project Evaluation:

- Nitrogen Removal Efficiency (utility and cost effectiveness)
- Overall Ease of Monitoring (cost benefit and enhancement of performance data collection to meet demonstration goals)
- Accessible Well Locations
- Quantity/Quality of Existing Information (cost benefit)

Other/Overriding Considerations:

- Community Acceptability
- Potential for Public Education
- Potential for Watershed/Estuary Impacts (distance from surface water and wetland resource areas/ water use considerations)
- Funding Potential
- Potential for Full Scale Implementation

2) Analysis

The PRB Technical Team collected site specific information, conducted site visits, and evaluated the potential performance effectiveness of selected PRB locations with the WatershedMVP utility. 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.

For the Site Suitability criteria, if a site was fully suitable based on the criterion being ranked, it was assigned a numerical value of 1. If the site was mostly suitable based on the criterion being ranked. It was assigned a ranking of 0 and if the site was mostly unsuitable, it was assigned a ranking of -1.

For the Permitting criteria, if a site was likely to be permitted and attain all regulatory approval based on the criterion being ranked, it was assigned a numerical value of 1. If the site was likely to be permitted, but there were potential issues related to the criteria, it was assigned a ranking of 0. If the site was more difficult to permit and receive all regulatory approval, it was assigned a ranking of -1.

For the Project Evaluation criteria, if a site was likely to produce a representative PRB demonstration based on the criterion being ranked, it was assigned a numerical value of 1. If the site was probably able to produce a representative demonstration it was assigned a ranking of 0. If a demonstration was unlikely to be representative at a site it was assigned a ranking of -1.

Quantitative rankings were tabulated in the Site Selection Matrix (Table 2). Results of the PRB site evaluation are discussed in Section 6.

6. Findings and Recommendations

The site suitability evaluation process narrowed the list of potential Demonstration Test sites to the following four locations:

1) Main Street and Tonset Road (Site A);

2) South Orleans Road at Tonset/Eldredge Parkway (Site B);

3) Town Cove Gibson Road (Site C); and

4) Town Landfill (Site E).

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 within Orleans. One additional demonstration site was identified at the Town Landfill (Site E). A demonstration test he landfill site could also be implemented given sufficient funding.

7. References

Cape Cod Commission 1995, Orleans Water Table Mapping Project

Howes B., S. W. Kelley, J. S. Ramsey, R. Samimy, D. Schlezinger, E. Eichner (2012). Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Nauset Harbor Embayment System Towns of Orleans and Eastham, Massachusetts

Howes B., S. W. Kelley, J. S. Ramsey, R. Samimy, D. Schlezinger, E. Eichner (2006).

Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Pleasant Bay, Chatham, Massachusetts. Massachusetts Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA.

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

Walter, D.A., Masterson, J.P., and Hess, K.M., 2004, Ground-water recharge areas and travel times to pumped wells, ponds, streams, and coastal water bodies, Cape Cod, Massachusetts: U.S. Geological Survey Scientific Investigations Map I-2857, 1 sheet [http://pubs.usgs.gov/sim/2004/2857/].

Wright-Pierce, December 2010, Town of Orleans Comprehensive Wastewater Management Plan and Single Environmental Impact Report.

270 Parcels
96,500 GPD

286 Parcels
45,600 GPD

178 Beach Road

223 Beach Road

Tri-Town Site

9 West Road

Potential Reclaimed Water Line

Clover Leaf Route 6A

29 Baker's Pond Road

Potential Disposal/Treatment Site in Brewster Site A

Potential Disposal/Treatment Site in Brewster Site B

Rock Harbor
Little Namskaket
Namskaket
Cedar Pond
Town Cove
Mill Pond
Meetinghouse Pond
Uncle Harvey's Pond
Upper River
Crystal Lake
Lonies Pond
Pochet
Baker's Pond
Pilgrim Lake
Lower River
Namequoit River
Arey's Pond
Uncle Israel's Pond
Twinings Pond
Sarah's Pond
Shoal Pond
Meadow Bog Pond
Deep Pond
Quanset
PLEASANT BAY
HARWICH
CHATHAM

Legend

- Floating Constructed Wetlands
- Coastal Habitat Restoration
- PRB_hybrid
- Aquaculture Area
- Coastal Habitat Restoration Area
- Floating Constructed Wetlands Area
- Potential Reclaimed Water Line
- Potential Reclaimed Water Sites
- Landfill
- 4 Nauset Middle School
- B Tri-Town
- Downtown Sewered Area
- Meetinghouse Sewered Area

Potential Disposal/Treatment Sites

- Site 5 - Tri-Town Disposal
- Site 6 - Tri-Town Disposal
- Site 7 - Tri-Town Disposal
- Site 15 - Meeting house/Pochet Treatment/Disposal
- Site 16 - Meeting house/Pochet Treatment/Disposal
- Site 21 - S. Orleans Treatment/Disposal
- Watershed Boundary
- Subwatershed Boundary

General Notes
1. 25% Nitrogen reduction from fertilizer management is applied to all watersheds.
2. All non-sewered area septage to be hauled and treated at the Tri-Town facility.
3. Sludge from decentralized treatment systems to be hauled and treated at the Tri-Town facility.
4. Wastewater flows based on current parcel water usage.
5. Map locations shown for Non-Traditional technologies illustrate scale.Specific siting will occur during project planning and design.

Stantec

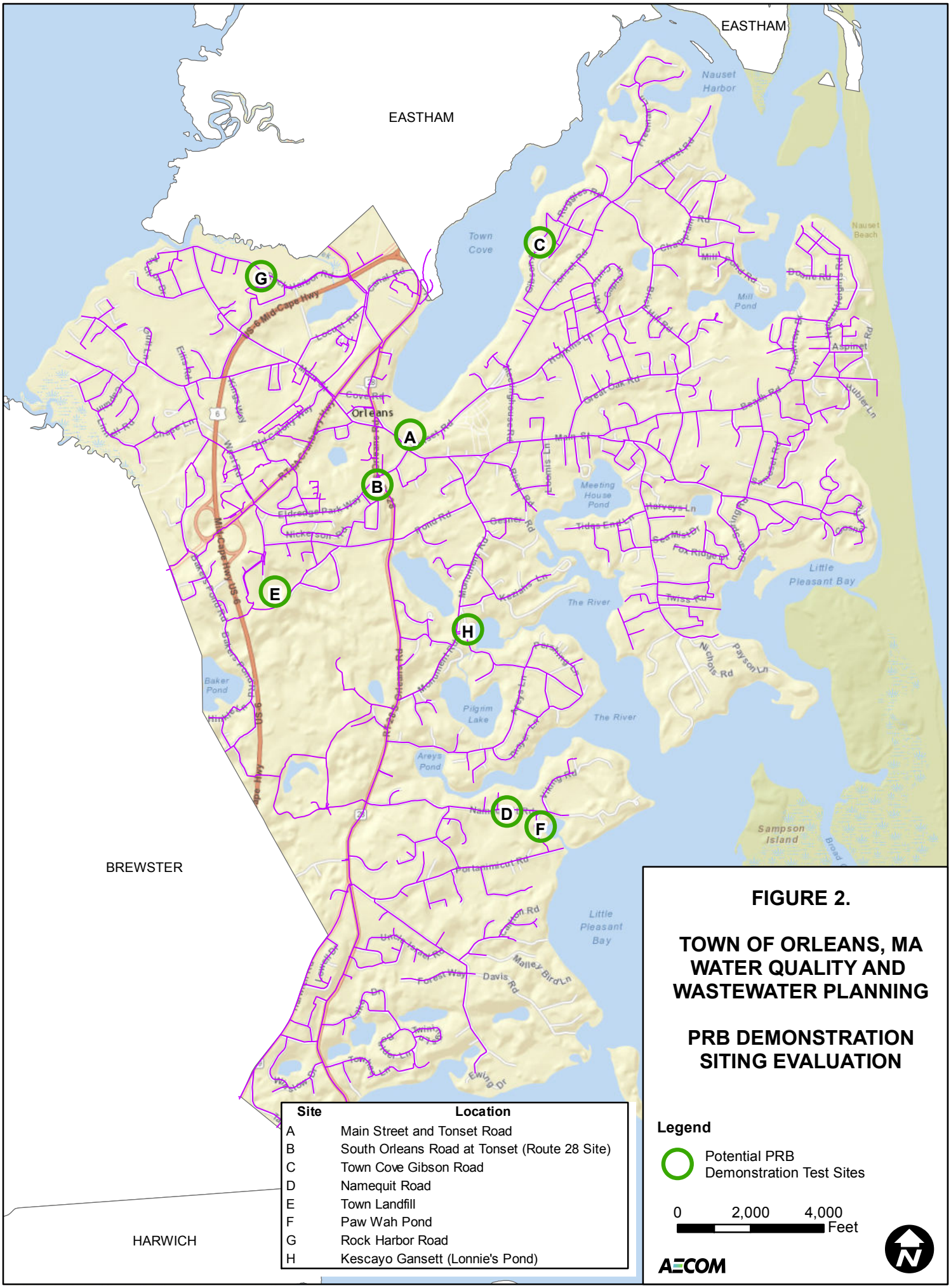
ORLEANS HYBRID VERSION 3
WQAP MEETING 2-11-15

TOWN OF ORLEANS
MASSACHUSETTS

FEBRUARY, 2015

N

0 600 1,200 2,400 3,600 4,800
Feet



Site	Location
A	Main Street and Tonset Road
B	South Orleans Road at Tonset (Route 28 Site)
C	Town Cove Gibson Road
D	Namequit Road
E	Town Landfill
F	Paw Wah Pond
G	Rock Harbor Road
H	Kescayo Gansett (Lonnie's Pond)

FIGURE 2.

TOWN OF ORLEANS, MA WATER QUALITY AND WASTEWATER PLANNING

PRB DEMONSTRATION SITING EVALUATION

Legend

Potential PRB Demonstration Test Sites

0 2,000 4,000 Feet

AECOM

C:\work\60476644ORL\Maps\PRB_Fig2_DemonstrationSiting_v3.mxd

Figure 3. MVP Calculated Nitrogen Load Removed - Full Scale PRB

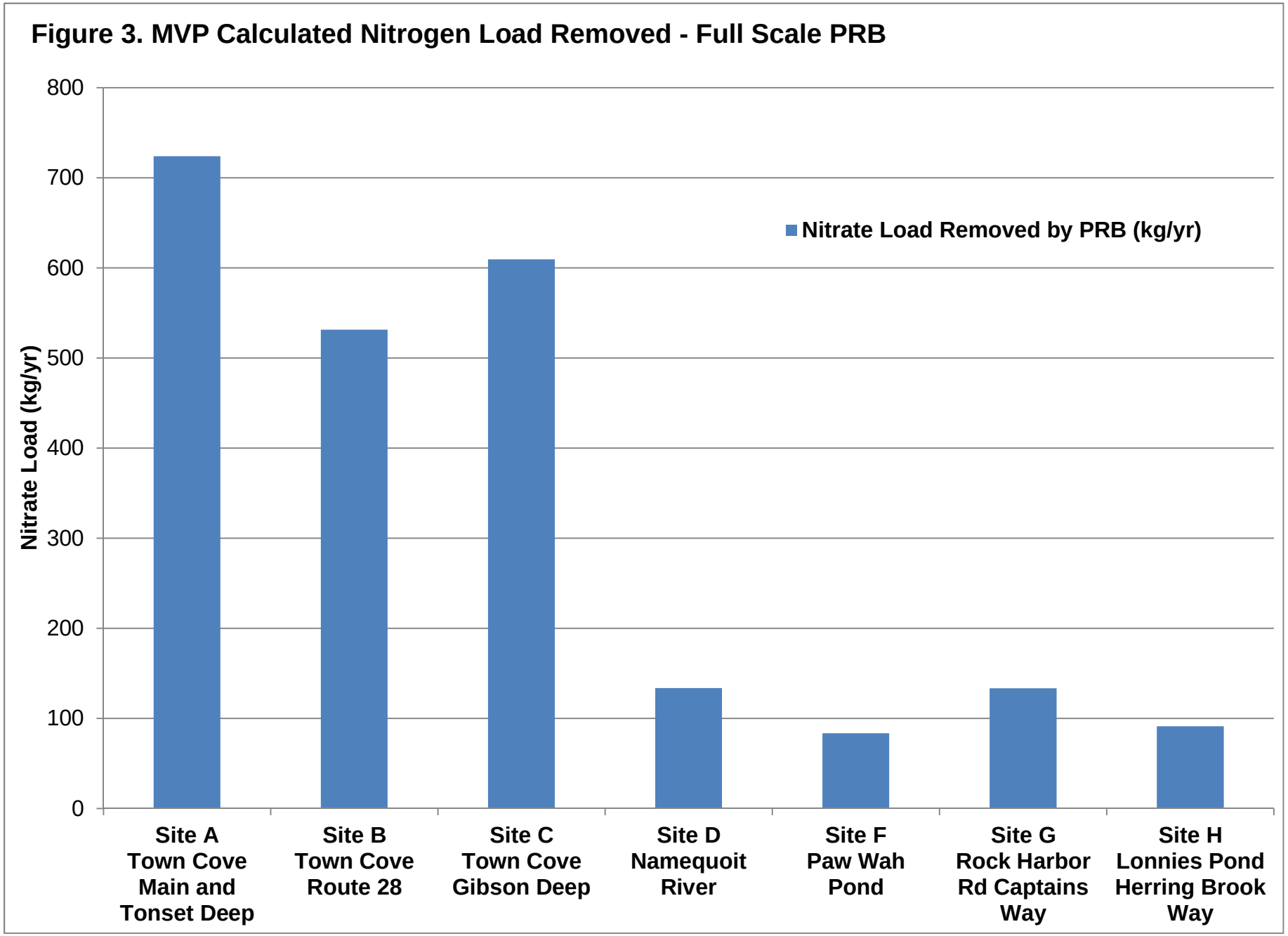


Figure 4. MVP Calculated Nitrate Load Removed Per PRB Length Unit

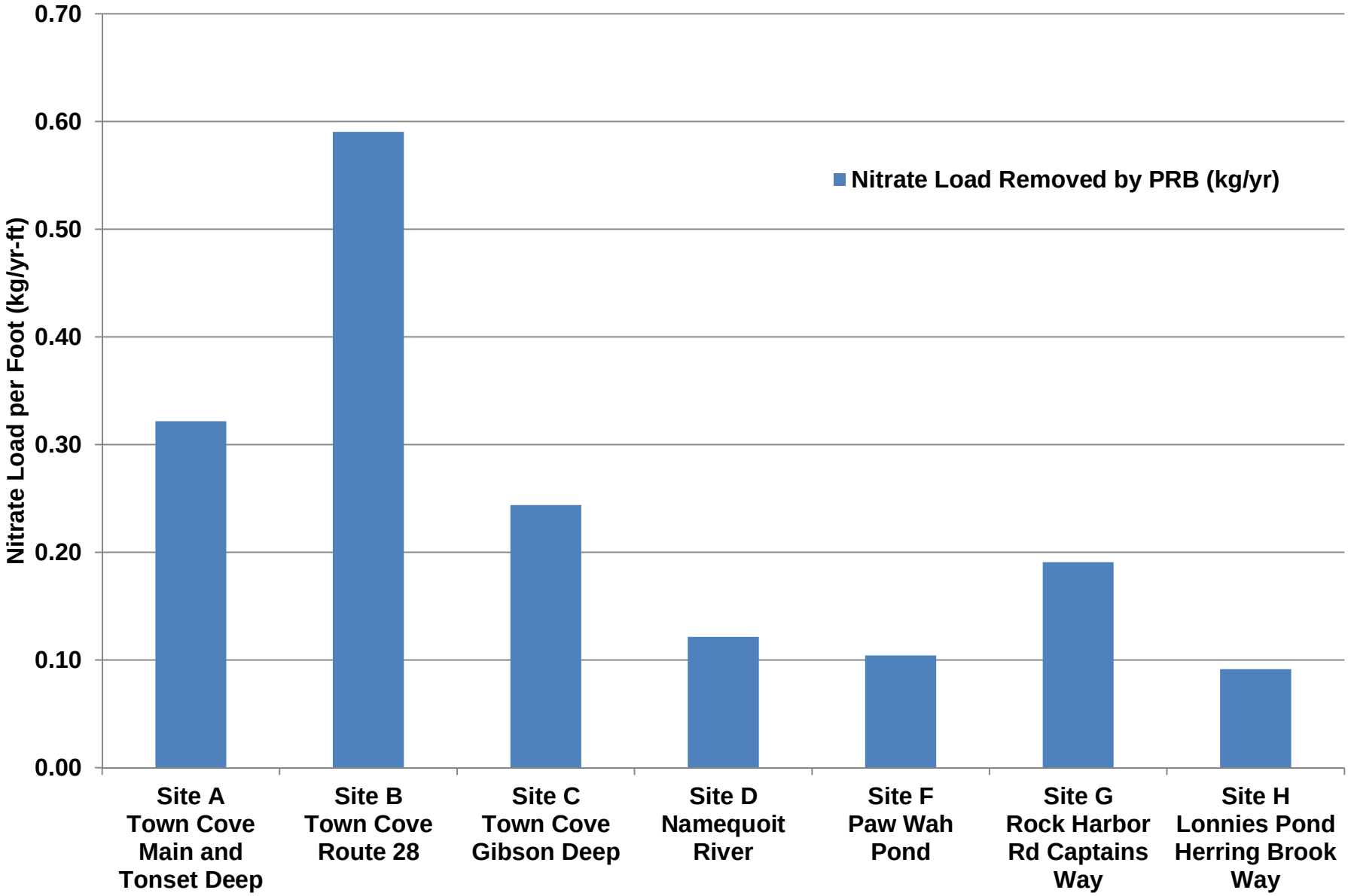


Table 1 WatershedMVP PRB Scenario Summary													
Scenario Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Description	Site A Town Cove Main and Tonset Deep	Town Cove Tonset Only	Town Cove Main St Only	Town Cove Main and Tonset Shallow	Site B Town Cove Route 28	Town Cove Gibson and Ruggles	Town Cove Ruggles Shallow	Site C Town Cove Gibson Deep	Town Cove Gibson And Ruggles Shallow	Site H Lonnies Pond Herring Brook Way	Site D Namequoit River	Site F Paw Wah Pond	Site G Rock Harbor Rd Captains Way
Total Properties In PRB Capture Area	192	95	97	96	104	272	55	217	137	36	38	23	38
Total Unsewered Properties In PRB Capture Area	192	95	97	96	104	272	55	217	137	36	38	23	38
MVP Estimated Nitrate Load (Sewer, Fert, Storm) In kg/yr	965	565	400	487	708	1,014	201	813	560	122	178	111	178
Nitrate Load From Other Sources (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Nitrate Load (kg/yr)	965	565	400	487	708	1,014	201	813	560	122	178	111	178
Percent Nitrate Reduction From PRB	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Nitrate Load Removed by PRB (kg/yr)	724	424	300	365	531	760	151	609	420	91	134	83	134
PRB Length (Feet)	2,250	1,300	950	2,250	900	3,725	1,225	2,500	3,725	1,000	1,100	800	700
Nitrate Load Removed Per Foot of PRB (kg/yr/ft)	0.322	0.326	0.316	0.162	0.590	0.204	0.123	0.244	0.113	0.091	0.122	0.104	0.191
Relative Estimated PRB Depth into Aquifer	Deep	Deep	Deep	Shallow	Shallow	Deep	Shallow	Deep	Shallow	Deep	Deep	Shallow	Deep

Town of Orleans, Massachusetts
Water Quality and Wastewater Planning
Table 2 - Permeable Reactive Barrier (PRB) Demonstration Siting Evaluation

Criteria	Criteria Weight	Site A Main Street and Tonset Road		Site B South Orleans Road at Tonset (RT-28 Site)		Site C Town Cove Gibson Road		Site D Namequoit Road		Site E Town Landfill		Site F Paw Wah Pond		Site G Rock Harbor Road		Site H Kescayo Gansett (Lonnie's Pond)	
		Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Site Suitability																	
Downgradient Potable Water Use - Wells	1	1	1	1	1	1	1	0	0	1	1	0	0	1	1	1	1
Topography	1	1	1	1	1	0	0	-1	-1	0	0	-1	-1	1	1	1	1
Depth to Groundwater	1	1	1	-1	-1	0	0	-1	-1	-1	-1	1	1	1	1	1	1
Groundwater Nitrogen Profile (concentration/depth)	1	1	1	1	1	-1	-1	-1	-1	1	1	-1	-1	-1	-1	-1	-1
Groundwater Flow Direction and Velocity	1	0	0	1	1	0	0	0	0	1	1	0	0	-1	-1	1	1
Ease of Access/Use of Property	1	1	1	1	1	-1	-1	1	1	1	1	-1	-1	1	1	0	0
Representativeness	1	1	1	1	1	1	1	-1	-1	0	0	-1	-1	0	0	-1	-1
Permitting																	
Outside ACEC, Upland Areas	1	1	1	1	1	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1
Abutter Compatibility	1	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0
Property Ownership/Road Layout	1	0	0	1	1	1	1	1	1	1	1	-1	-1	0	0	-1	-1
Utility Conflicts	1	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Project Evaluation																	
PRB Nitrogen Removal Efficiency	1	1	1	1	1	0	0	0	0	1	1	0	0	0	0	0	0
Overall Ease of Monitoring	1	0	0	1	1	0	0	0	0	0	0	-1	-1	0	0	-1	-1
Accessible Well Locations	1	0	0	1	1	1	1	1	1	0	0	-1	-1	0	0	0	0
Quantity/Quality of Existing Information	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Other/Overriding Considerations																	
Community Acceptability	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Potential for Public Education	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Potential for Watershed/Estuary Impacts	1	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0
Funding Potential	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potential for Full Scale Implementation	1	1	1	1	1	1	1	0	0	0	0	-1	-1	-1	-1	0	0
Total Criteria Points			**10**		**15**		**6**		**0**		**11**		**(7)**		**3**		**0**
Rank			**3**		**1**		**4**		**-**		**2**		**-**		**5**		**-**

Notes:
High Criteria Weight = Greater Importance
Higher Rating = Better Conditions

Remarks

ATTACHMENT L

TECHNICAL MEMORANDUM – PRELIMINARY ENGINEERING WORK PLAN FOR PERMEABLE REACTIVE BARRIERS

AECOM
9 Jonathan Bourne Drive
Pocasset, MA 02559
www.aecom.com

508.833.6950 tel
508.833.6951 fax

Memorandum

To	George Meservey, Director of Planning & Community Development Michael Domenica, PE, Program Manager
CC	Betsy Shreve, AICP, AECOM Project Director Sia Karplus, Science Wares, Inc. AECOM PRB Team
Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 3.3 – NT Demonstration Projects** **Technical Memorandum Final for Preliminary Engineering Work Plan for Permeable Reactive Barriers**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	May 19, 2016

1. Background

a. This technical memorandum presents the Preliminary Engineering Work Plan for Permeable Reactive Barriers (PRBs). AECOM Technical Services, Inc. (AECOM) PRB Technical Team (AECOM and MT Environmental Restoration) prepared this Preliminary Engineering Work Plan for PRBs for the Town of Orleans. AECOM is providing water quality and wastewater planning and engineering services to the Town to reduce excessive nitrogen loading to the Town's ponds, estuaries and embayments.

2. Introduction

a. The Project represents the first to implement a "Hybrid" approach under the Cape Cod 208 Water Quality Plan, which has been approved by both the United States Environmental Protection Agency (USEPA) and the Massachusetts Department of Environmental Protection (MassDEP). The Project consists of conceptual and preliminary design to update the Comprehensive Wastewater Management Plan (CWMP) completed by the Town in 2011 to reflect the Consensus Plan (Water Quality Management Plan) developed by the Town in 2015. The Project goal is to minimize the proposed sewered footprint (area of Town and number of properties to be sewered) to the greatest extent possible by maximizing the use of several non-traditional technologies (Coastal Habitat Restoration, Aquaculture, Floating Constructed Wetlands, and Permeable Reactive Barriers). The Hybrid Plan was vetted through the Orleans Water Quality Advisory Panel (OWQAP), a panel consisting 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. Potential alternative planning scenarios to meet water quality standards were developed for the OWQAP.

b. The purpose of this preliminary engineering work plan is to describe proposed Demonstration Tests for PRBs. PRBs are a non-traditional wastewater treatment technology with the potential to reduce the levels of nitrate in the groundwater by treating groundwater biologically before it reaches sensitive surface water bodies. This work plan will identify selected Demonstration Test locations and present preliminary engineering design criteria. Additionally, initial permitting requirements, cost estimates, and monitoring plans will be presented. The monitoring plans will be incorporated into an overall Adaptive Management Plan which will be implemented to evaluate the impacts of the technologies on reducing nitrogen. AECOM is working closely with the Town, its Water Quality Advisory Panel, and the regulatory agencies including the Cape Cod Commission and MassDEP, as the Adaptive Management Plan is critical to obtaining one of the first watershed permits granted by MassDEP.

c. 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.

3. Selection of Demonstration Test Location(s)

a. AECOM evaluated numerous potential sites in the Town of Orleans, including locations identified by the Town, for consideration for placement of PRB Demonstration Tests in 2016. Property ownership and use, upgradient land use and density, downgradient groundwater use, distance to shoreline, nitrate concentrations and flux, topography, overall ease of monitoring, and potential for full scale PRB implementation were among the criteria evaluated and rationale for selection of sites for performing the Demonstration Test. The resulting Technical Memorandum on Site Characterization for Permeable Reactive Barriers (Characterization Memo) is included as Appendix A, which includes figures showing the locations of each of the sites evaluated. The evaluation process narrowed the list of potential Demonstration Test sites to the following four locations shown on Figure 3-1:

   1) Main Street and Tonset Road (Site A);

   2) South Orleans Road at Tonset/Eldredge Parkway (Site B);

   3) Town Cove Gibson Road (Site C); and.

4) Town Landfill (Site E).

b. Based on further evaluation for the preparation of this Work Plan, a preferred Demonstration Test site at Eldridge Park (Site B) was selected based on key location features, available data, and the ability to provide results representative of other areas in the Town. One additional potential demonstration site, the Town Landfill (Site E) was identified as 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 3-2.

c. The Town-owned Eldredge Park Demonstration Test site is located in the parking lot area between the playing fields off Eldredge Parkway (Figure 3-3). 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. Several groundwater monitoring wells were installed for a separate investigation at the Police Station (less than 500 feet east), and the depth to groundwater is approximately 30 feet using these wells. Additional groundwater monitoring wells were identified at the Nauset Regional Middle School (NRMS) in the recreational field and parking lot area. These wells were installed in 1992 as part of an ongoing program to monitor groundwater in the vicinity of the NRMS wastewater disposal system and leaching fields. An irrigation well for Eldredge Park was also identified near the corner of Eldredge Parkway and South Orleans Road with available boring logs and groundwater quality data. A significant mass flux of nitrate in groundwater is expected at the preferred Demonstration Test location (estimated 710 kg/yr as calculated with WatershedMVP), and the groundwater flows from this area toward Town Cove to the northeast. The parking lot area provides sufficient room for both the layout of the PRB and upgradient and downgradient monitoring wells.

d. The Orleans landfill is the second preferred location for a PRB Demonstration Test (Figure 3-4). An ongoing groundwater monitoring program has found significant concentrations of nitrate in groundwater at the landfill (10 to 40 mg/L). These concentrations are likely significantly higher than concentrations that may be found over a wide area of Town from septic system sources. Historical landfill and septage lagoon operations began operation around 1950 and are likely sources of nitrate in groundwater at the landfill. Ongoing yard waste composting may also be a contributing source of nitrate infiltrating with stormwater runoff. The depth to groundwater is approximately 45 feet below grade at the lowest point of land elevation at the landfill but increases significantly downgradient as the land surface is higher. The landfill is near the top of the Nauset watershed and groundwater flows from the landfill northeast in the direction of Town Cove. Estimates for travel time from the landfill to Town Cove are uncertain and may be as much as 50 years.

e. A third potential Demonstration Test site location along a portion of Gibson Road at the intersection with Asas Landing was also considered (see Figure 4-4). However, given the low concentration of nitrate found during the groundwater investigation (reported below), the location does not appear to be a suitable Demonstration Test location.

4. Basis of Design

a. Nitrogen loading from point and non-point sources is impacting surface water quality in Orleans and Cape Cod in general. A significant portion of this nitrogen load is transported to surface

water via groundwater flow. PRBs can intercept and remove part of this nitrogen load from the groundwater system.

The basis for designing effective PRB demonstration tests and full scale PRBs is a Conceptual Site Model (CSM) for the problem. The CSM is an understanding of conditions based on information including sources of nitrogen in groundwater, migration pathways, transport mechanisms, and fate of nitrogen in groundwater. Most of the current understanding of the problem has been developed through assessments of land use and sources of nitrogen, local groundwater data from investigations associated with water supplies, regional groundwater hydrogeology studies, and assumptions based on groundwater geochemistry.

Individual on-site septic systems are used to manage about 85 percent of the wastewater flow from residences and businesses on Cape Cod (Cape Cod Commission, 2013). Many of these systems are simple leaching pits and cesspools installed decades ago. Septic systems that process wastewater flows up to 10,000 gallons per day are regulated under Title 5, the state's sanitary code for on-site wastewater systems (310 CMR 15.00). These systems are permitted by local Boards of Health and the MassDEP. Title 5 septic systems were designed to remove pathogens and not nutrients. Dissolved nitrogen from waste material travels through a septic tank and into leach fields down to groundwater. Bacterial reactions transform organic nitrogen to ammonia in the septic tank, and below and downgradient of the leach field, under aerobic conditions, the ammonia is converted by bacteria to nitrate. As a result, nitrate-laden groundwater emanating from septic systems travels as a plume without significant attenuation in groundwater to Cape Cod's coastal waters (Cape Cod Commission, 2013). Additional nitrate from lawn fertilizer and stormwater infiltration adds to the groundwater nitrogen load. Areas of more dense development will have multiple plumes that may merge to form a large dilute nitrate plume, transporting a significant nitrogen mass or nitrogen load toward downgradient surface waters.

Regional groundwater flow systems have been mapped for the Nauset, Pleasant Bay, and Cape Cod Bay watersheds in the Town of Orleans. These maps show watershed boundaries or divides that separate one flow system from the next and may include approximate groundwater elevation contours. Groundwater generally flows from the highest water table elevations in the watershed (e.g. approximately 26 feet above sea level in the Nauset Watershed) downgradient toward the receiving surface water body (e.g. Town Cove). In addition to flowing horizontally downgradient, groundwater may flow vertically, recharging deeper portions of the aquifer 100 to 150 feet or more below sea level. Water table elevations vary locally resulting in deviations in local groundwater flow direction. Groundwater velocity will vary depending on the local groundwater gradient and hydraulic conductivity of the aquifer material. The aquifer material may contain less permeable clay, silt or fine sand or higher permeability medium sand and gravel. The groundwater velocity may vary from less than 0.1 feet per day to more than 3 feet per day depending on local conditions.

This CSM can be used to design PRB demonstration tests that will be representative of conditions over a wider area, ideally focused on a location with high nitrate flux through the PRB to prove the process, and provide key information for PRB design.

b. Hydrogeologic, Geochemical, and Nitrogen Data collection

1) AECOM completed hydrogeological investigations at selected sites in the Town within the Nauset watershed 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 CSM)

developed for each of the potential sites was updated with the additional data from site specific investigations. The information used to update the CSMs included:

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

2) 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 Asas Landing; and
4. Orleans Town Landfill.

Locations of monitoring wells sampled by AECOM are shown in Figures 4-1 through 4-4 and Figure 3-4 for the landfill. Figure 4-5 presents an aerial view of all of the wells in the Nauset watershed area between the landfill to Town Cove. Sampling locations included existing monitoring wells within the areas of interest identified through records search and newly installed monitoring wells by AECOM. Existing monitoring wells at selected locations were also included in the investigation.

3) At each location, soil borings were advanced to record soil classification with depth, and multi-level groundwater monitoring wells were installed. Soil boring were installed with a Geoprobe 6600 direct push rig, and soil core samples were collected from the deepest soil boring at each location for soil type characterization with depth. Monitoring wells were constructed with 2-inch Schedule 40 PVC casings and 10 foot screens (Schedule 40 PVC .010" 10 slot well screen). Each new well location has two or three discrete screened intervals to collect groundwater samples at different depths. The deepest screen was designated the “A” screen and installed approximately 20 to 30 feet below the water table. The “B” screen was placed approximately 10 to 20 feet below the water table, and the “C” screen was placed from the water table to 10 feet below the water table. Monitoring well construction details are included in Table 1. Boring logs are included in Appendix B.

4) Monitoring wells were surveyed by Coastal Engineering for location and top of casing elevation. Top of PVC casing elevations are included in Table 1, and the well coordinates are included in Appendix B. The depths to groundwater from the top of well casings were used to determine groundwater elevations and the local direction of groundwater flow. Groundwater elevation data is included in Table 2. Groundwater contours based on data collected in February 2016 are presented on Figure 4.5.

5) Groundwater samples were collected for laboratory analyses to assess groundwater quality related to PRB design and concentrations of nitrogen species. Groundwater parameters (pH, temperature, dissolved oxygen, oxidation-reduction potential, and conductivity) were monitored during sample collection with a multi-parameter probe in a flow-through cell prior

to sampling. All groundwater samples were submitted to the ESS Laboratory for analyses of nitrate as nitrogen, nitrite as nitrogen, ammonia as nitrogen, total nitrogen, chloride, and sulfate. Selected samples were also analyzed for dissolved iron, dissolved manganese, boron, and dissolved organic carbon (DOC).

A summary of field and laboratory groundwater data is presented in Table 3. Laboratory reports with results of analyses can be found in Appendix H. A reference background nitrate concentration, unaffected by wastewater disposal, of 0.46 mg/L was previously reported for Cape Cod by the United States Geological Survey (USGS) (LeBlanc, 1984). Earlier data from Frimpter and Gay, 1979, indicate uncontaminated groundwater may have less than 0.1 mg/L nitrate nitrogen. Generally, as expected, nitrate concentrations were highest where aerobic conditions were observed and lower where anoxic conditions were observed.

Key findings from the investigation for potential Demonstration Test sites were as follows:

1. Main Street and Tonset Road (Main Street)

    a. At the Snow Library monitoring well location the highest oxygen levels were found in the shallowest screened well (MW-A3-C) and relatively low but still aerobic levels of oxygen were encountered in the deeper screens, MW-A3-B and MW-A3-A. Nitrate was detected at all monitored intervals at approximately the same concentration, just under 2 mg/L. Some ammonia was detected in the shallow intervals, potentially from nearby septic leach fields.

    b. Adjacent to 82 Main Street, nitrate was detected in the middle (MW-A1-B) and deep well screens (MW-A1-A) at 3 to 5 mg/L where groundwater conditions were observed to be aerobic. The highest concentration was detected in the deep well. Anaerobic groundwater and higher DOC were observed in shallow groundwater (MW-A1-C); nitrate concentrations were measured to be lower in shallow groundwater, due to likely denitrification occurring under existing conditions.

    c. Groundwater contours indicate groundwater flow in the vicinity of Main Street is to the east northeast, generally toward the southeast corner of Town Cove.

2. South Orleans Road at Tonset/Eldredge Parkway (Route 28 site)

    a. Pre-existing monitoring wells with long term data show elevated nitrate concentrations as high as 22 mg/L.

    b. Groundwater elevation data indicates a significant groundwater gradient and likely fast groundwater flow.

    c. The combination of high nitrate concentration and fast groundwater flow indicate a high flux of nitrate through the area with flow toward Town Cove making this a prime Demonstration Test location.

3. Gibson Road at Asas Landing

a. Nitrate was detected at less than 1 mg/L in the two level multi-level well installed on Asas Landing (MW-G1-A and MW-G1-B). Based on background information and this limited data, the Gibson Road area may not be a prime location for a Demonstration Test.

4. Orleans Town Landfill

a. Data from previous investigation have shown high concentrations of nitrate and a significant flux of nitrogen in groundwater.

b. Additional data collected at the Landfill from the new monitoring wells installed for this assessment and selected existing wells confirmed the groundwater flow direction to the northeast toward Town Cove.

c. Additional data also confirmed the presence of high ammonia concentration in deep groundwater (MW-5D). A Demonstration Test PRB would only be applicable to shallow groundwater where nitrogen predominantly in form of nitrate. Treatment of deeper groundwater where ammonia is present would require the use of additional technologies.

c. PRB Treatment Process Description

1) PRBs are a passive treatment technology, designed in this application to intercept and treat nitrate in groundwater by biological denitrification before groundwater reaches downgradient surface waters. The PRB treatment zone is located in the groundwater saturated zone below the water table, where amendments are added to form the PRB. PRBs are typically oriented perpendicular to the direction of groundwater flow and rely on the natural groundwater gradient to carry the contaminant through the PRB (ITRC, 2011). The system is permeable because the amendments added do not interfere with groundwater flow, and nitrate is removed as groundwater passes through. A PRB would be most cost effective where groundwater transport of nitrogen is significant, with higher nitrate concentration and a relatively fast groundwater velocity, resulting in a high mass flux of nitrate through the treatment zone. It is this mass flux of nitrogen that contributes to nitrogen loading to downgradient surface waters.

2) As described in the Cape Cod Area Wide Water Quality Management Plan Update (Cape Cod Commission, 2015), PRBs are a non-traditional method for biologically mediated nitrate reduction or denitrification. This in-situ (in place in the ground) treatment method typically introduces a carbon food substrate into the groundwater, allowing naturally occurring microbes in the groundwater to consume the carbon substrate while respiring oxygen and creating anoxic conditions (without oxygen) favorable for denitrifying bacteria. Under anoxic or anaerobic conditions, maximum energy is gained by microbes using nitrate as an electron acceptor (denitrification reaction), followed by reduction of manganese, reduction of iron, and reduction of sulfate. Therefore, nitrate is the preferred electron acceptor to soil microbes after oxygen is consumed. This process of bacterial metabolism results in the conversion of nitrate to inert nitrogen gas and requires both anoxic conditions and sufficient food substrate for bacterial growth.

Denitrification: $NO_3^- \rightarrow NO_2^- \rightarrow NO + N_2O \rightarrow N_{2\,(g)}$

3) In-situ enhanced bioremediation via denitrification with PRBs has been implemented for treatment of nitrates in groundwater using various carbon substrate/electron donors, including using large scale PRBs (ITRC, 2011; Pinter, 2014). Recent sand column studies conducted with aquifer materials and groundwater from a Falmouth, Massachusetts site have shown very good nitrate removal performance using an organic carbon substrate for biostimulation (Terra Systems, 2016)). PRBs formed by the addition of a carbon substrate as an electron donor have also been applied at thousands of sites for treatment of chlorinated solvents. Naturally occurring bacteria that degrade chlorinated solvents require sufficiently reducing conditions (sulfur-reducing and/or methanogenic conditions) to stimulate microbes to respire these compounds. In order to generate sufficiently reducing conditions, other competing electron acceptors (oxygen, nitrate, manganese, and sulfate) need to be consumed by other bacteria first. Therefore, at all successful enhanced bioremediation sites for chlorinated solvents, any nitrate in groundwater would be consumed via denitrification in order for anaerobic dechlorination reactions to occur. Nitrate concentrations in groundwater before and after application of emulsified vegetable oil at several AECOM sites are presented in Appendix C as examples.

5. Permitting

The EPA Underground Injection Control (UIC) Program is responsible for regulating the construction, operation, permitting, and closure of injection wells that place fluids underground for storage and disposal. The UIC Program requirements were developed by EPA and designed to be adopted by states. The Massachusetts Department of Environmental Protection (MassDEP) UIC Program is defined in 310 CMR 27.00: Underground Injection Control Regulations and details the regulation of injection of fluids within Massachusetts.

To implement the Demonstration Test a UIC permit application (MassDEP form BRPWS 06) will be filed with MassDEP under the category “Aquifer Remediation.” Similar injections of carbon substrates to enhance biodegradation of groundwater chemicals have been commonly implemented in Massachusetts, and many of these sites are exempt from the UIC registration process if the injections are conducted for waste site cleanup in accordance with the Massachusetts Contingency Plan (MCP, 310 CMR 40.0000) or similar federal statutes. In implementing the Demonstration Test all injections associated with the PRBs will comply with the requirements of the Massachusetts UIC regulations and the MCP requirements, including all required monitoring.

An example UIC permit is submitted alongside this work plan for the PRB Demonstration Test. The UIC permit application is included as Appendix D. A fee of $585 for each site would be associated with filing the UIC permit. The UIC permit applications should be submitted at least 60 days in advance of the proposed PRB demonstration test start date.

6. Demonstration Test Design

This section details the design components and critical assumptions for planning and implementing PRB Demonstration Tests.

a. Size of Demonstration Tests

As described in Section 3, a prioritized list of two recommended PRB Demonstration Tests has been proposed. The proposed demonstration sites will generally each include one line of injection points spaced 10 feet apart. The approximate locations of the proposed PRBs are shown on Figure 3-3 and Figure 3-4 for Eldredge Park and the Landfill, respectively. Demonstration Test PRB lengths are as follows: (a) Eldredge Park 200 feet; and (b) Landfill Demonstration 50 feet.

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. The full depth of significant nitrate concentrations at these sites is unknown. Ammonia concentrations may be more significant at depths more than 40 feet below the water table at the Landfill.

b. Reactive Amendment Application Methods

PRBs have been designed and implemented through several construction methods, including backfilling an excavated trench with reactive media (using standard construction excavator), continuous trenching using one-pass trencher, drilling auger boreholes backfilled with reactive media, through injection for the application of reactive media, and electrochemical methods.

Various site-specific factors determine the method selected, including the depth and width of the PRB, the reactive media, quantity of reactive media, the site geology, and the surface/subsurface obstructions present (ITRC, 2011). The main options for construction are trench installations with wood mulch carbon substrate and injection (with or without permanent injection wells) of liquid organic carbon substrates such as emulsified vegetable oil. Table 6-1 provides the pros and cons of these construction methods.

Table 6-1. Comparative Evaluation of Permeable Reactive Barrier Installation Methods

Conventional Excavator Installation - Mulch Permeable Reactive Barrier	
Advantages	**Disadvantages**
• Mulch PRBs widely accepted groundwater treatment method and construction equipment readily available	• Requires large construction equipment
• Reactive media (mulch) has no potential to migrate	• Requires soil handling and disposal plus area to stage soils
• Treatment longevity of trench typically longer than injection-based methods	• Reactive zone (residence time) limited to trench width (3-4 feet)
	• Limited flexibility in alignment to accommodate above and below ground site features
	• May lead to settling of ground surface over time
	• Not suitable for placement in roadways due to settling
	• Requires future rejuvenation (often by injection of emulsified vegetable oil), instead of by replacing the trench through excavation)
	• Limited to depth of 20 feet below surface, which would require placing PRB in proximity to surface water. ❖ Not likely to reach target depths for treatment ❖ PRB trench may not treat entire vertical zone required ❖ Challenge to permit project adjacent to surface water ❖ A PRB located very close to surface water resource would not provide sufficient downgradient travel time for stabilization of groundwater chemistry before groundwater discharge to the surface water (i.e., iron staining at surface water)
Injection – Food-grade carbon substrate	
Advantages	**Disadvantages**
• Locations of PRBs are flexible and can be located upgradient away from environmental resource areas.	• Liquid amendments can be transported short distances/diluted by groundwater flow (requires verification of stability).
• Carbon substrate injections widely accepted groundwater treatment method and equipment readily available.	• Injection PRBs likely would require replenishment sooner than trenches.
• Small equipment footprint (small drill rig, all pumps and mixing tanks contained to box truck/trailer.	

• Can be installed under roadways.	
• Limited impacts to traffic and abutters.	
• Orientation can be adjusted in the field to accommodate above and below ground site features (utilities, curbs, trees, overhead power lines).	
• Injection can generate a wider treatment zone (more residence time) than a trench filled with solid reactive media.	
• Application not limited by depth (for anticipated depths in Orleans).	
• Shorter field construction time than trenching.	
• Injection method can be pilot-tested at small scale cost-effectively.	

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 soy bean oil, to create a passive 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. Soil boring installation does not require permanent well covers at the surface that may be unacceptable in roadways. This concept was carried through in consideration of all potential PRB demonstration sites.

For the Demonstration Tests, PRBs are anticipated to be constructed through injection of reactive amendments to stimulate biological denitrification. Injected PRBs consist of a number of injection points arrayed perpendicular to groundwater flow and oriented in a configuration to establish a continuous zone of reactive media across a targeted width and vertical groundwater interval. Use of injection is proposed based on depths of treatment, anticipated locations of PRBs in/near roads and in residential or commercial zones, and known aboveground and subsurface utilities. Injection PRBs can be installed with small drill rig(s) and a truck or trailer with mixing tanks and pumps. Standard construction equipment would not be capable of reaching targeted depths (greater than 30 feet below grade), and one-pass trenchers are significantly more expensive than all other proposed methods. Excavation equipment and/or one-pass trenchers would be very disruptive to adjacent properties and traffic flow. Trenching alternatives are anticipated to have a longer field installation period than injection, and equipment for trenching methods requires a larger footprint (for both operations and equipment staging) than injection during operations. In addition, the trenching options would generate a significant volume of soil that would need to be disposed of off-site and would likely also require an area for stockpile staging. Injection points can also be adjusted in the field to accommodate above and below ground site features (utilities, curbs, trees, overhead power lines). Additional details on delivery of reactive media through injection are presented below.

c. PRB Demonstration Test Amendments and Systems

As discussed above there are various carbon sources that are available to be used as reactive media or electron donors. Solid substrates can be placed in augured boreholes. Substrates delivered as a liquid solution are most commonly injected.

Liquid solutions are anticipated for use for the Demonstration Test. Several proprietary and non-proprietary reductive amendments have been applied for enhancing anaerobic biodegradation in groundwater. Example amendments include water soluble substrates (e.g., lactate, molasses) and slow release substrates like emulsified vegetable oil (EVO).

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 for chlorinated solvents (as noted above). EVO is typically mixed with water to create an emulsion and allow for more effective distribution. 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. EVO is typically present in the subsurface for two to five years based on AECOM and remediation industry experience, allowing biodegradation reactions to persist for an extended period of time (AFCEE, 2004). Commercially available, remediation-grade EVO generally contains approximately five percent food-grade sodium lactate as a rapidly biodegradable substrate to initiate generation of anaerobic conditions as well as Vitamin B12 Supplement that provides additional nutrients to further enhance microbial activity and the rate of denitrification.

Subsurface geology on Cape Cod consists of relatively permeable sandy formations with high groundwater flow velocities (1 to 3 feet per day). For injection of EVO into aquifers with higher groundwater flow rates, an EVO solution with a larger droplet size is recommended such that the EVO droplets will adhere to sand grains in the formation to minimize the advection of EVO after injection. A larger droplet size will also maximize the persistence of the carbon substrate within the PRB. It is anticipated that a site-specific modified EVO formulation will be used for this application, including but not limited to droplet size, vitamin supplements, and other minor components (for example, surfactants). Product information, including the Material Safety Data Sheets (MSDS) for proposed EVO substrate is presented in Appendix E.

For in-situ remediation technologies, delivery of an appropriate amount of injected amendments is a primary factor to achieving successful treatment. Sufficient carbon substrate/electron donor must be applied to establish reducing conditions in the PRB. Calculations supporting amendment dosages are presented in Appendix F. The Substrate Estimating Tool for Enhanced Anaerobic Bioremediation of Chlorinated Solvents developed for the Environmental Security Technology Certification Program (ESTCP) was used to support EVO quantities for the PRB Demonstration Tests. This tool estimates quantities of various carbon substrates to provide sufficient amendment for the sum of electron donor demand from electron acceptors (dissolved oxygen, nitrate, and sulfate) as well as dissolved volatile organic compounds if present. For the Demonstration Tests sites, the EVO dosages were determined primarily to meet the electron donor demand based on typical conditions on Cape Cod including expected nitrate concentrations. The ESTCP EVO dosage calculations will be revised, if necessary, based on groundwater sampling to be performed by AECOM in 2016. Anticipated quantities of EVO for the Demonstration Test are summarized in Table 6-2 based on the calculations provided in Appendix F.

The metabolism of added carbon substrate by soil microbes can result in a decrease in groundwater pH, and a neutralization agent (i.e., sodium bicarbonate) is sometimes injected with the carbon substrate to counteract changes in pH. In addition, groundwater pH has been observed to be between pH 5.5 and pH 6 across Cape Cod. Denitrifying bacteria are most active

in circumneutral groundwater (pH 6 to 8), and sodium bicarbonate or other pH buffer could be considered based on pH conditions noted in the groundwater sampling to be conducted by AECOM in 2016.

Table 6-2. Summary of Design Parameters for Permeable Reactive Barrier Demonstration Tests

Parameter	Site B	Site E
Area Description	Parking lot between the playing fields off Eldredge Parkway	Town Landfill near Gift Shop
Depth to Ground Water	30-40 feet below grade	45-55 feet below grade
Demonstration Test PRB Length	200 feet	50 feet
Preliminary Target Treatment Thickness	40 feet	40 feet
Injection Point Spacing	10 feet	10 feet
Injection Points	20	5
Injection Target Pore Volume	6%	6%
Total Injection Volume (gal)	9,000	2,250
Injection Volume Per Point (gal)	450	450
Nitrate Concentration (mg/L)	5 - 15 mg/L	10 - 30 mg/L

d. Substrate Delivery

Injection of carbon substrates can be performed through semi-permanent PVC wells or directly through direct-push (i.e., GeoProbe®) rods. Advantages of semi-permanent wells are that future, follow-up injections can be completed without additional drilling activity, and the wells can be used as additional data collection points. Advantages of direct-push injections are that there is no well construction required so there is no added cost for well installation, maintenance, and abandonment. For the Demonstration Tests, the EVO will be injected into the subsurface using direct-push tooling. Advantages for the direct push injection method include:

1) Eliminates the need for installing and maintaining wells at proposed injection points that will be located in the road and other areas with vehicle traffic (i.e., parking lot). Such wells would be subject to damage from plows and other vehicles. Follow-up injection is not anticipated for the near-future based on the active lifetime of the selected EVO substrate (three to five years or more);

2) Avoids biological fouling (biofilm accumulation) problems in EVO injection wells that are not used for extended periods of time (maintaining wells and/or re-developing wells would be required prior to a future injection);

3) Avoids costs and effort associated with installing injection wells, including but not limited to drilling time and costs, elimination of soils for handling and disposal, and reduction of engineering oversight effort;

4) Reduces on-site construction time by not installing injection wells that would be disruptive to parcels of land used for the Demonstration Testing;

5) Costs associated with remobilization of direct-push injection equipment are relatively small compared to well maintenance costs; and

6) Injection amendment can be emplaced throughout a relatively deep interval in one direct push borehole.

Geological limitations observed during the Demonstration Test would be noted and could be rationale for incorporating injection wells for future/full-scale treatment. Injections to the groundwater will be performed using a regular-spaced line of injection points. Spacing of injection points will be approximately 10 feet, but actual spacing may vary in the field due to adjustments for surface and subsurface features. Injection using a row of closely spaced points is intended to establish a continuous barrier length to minimize potential for groundwater to flow through gaps in the reactive zone. Closely-spaced points reduces the injection volume of EVO at each point as well as the distribution of the EVO in the subsurface, which is intended to prolong the persistence of the EVO after injection. In addition, lateral dispersivity (an estimated measure of how particles flowing in groundwater stray to the sides from predominant groundwater flow direction) is generally low on Cape Cod. Therefore EVO and associated organic carbon and generated reducing conditions are expected to flow in a straight line and not spread out as groundwater flows from the injection point. Injection points will be offset at least five feet from known underground utilities (10 feet from water mains) or monitoring wells to minimize damage to utilities during drilling and to reduce the potential that the injected amendment does not short circuit through the utility conduits or well sand packs. Overhead utilities will also factor into the final location due to the safety concerns posed by the lines during injection point installation.

e. Application Dosage and Volume

Delivery of amendments is a primary factor to achieving a successful in-situ treatment. The main design considerations include test volume, soil porosity and grain size analysis, groundwater velocity, and amendment characteristics. Based on AECOM experience on other enhanced bioremediation projects, carbon substrate solutions will be injected at volumes equivalent to approximately five to fifteen percent of the pore volume in the Demonstration Test treatment areas (injection volume calculations provided in Appendix F). This volume is sufficient to generate reducing conditions favorable for denitrifying bacteria, not cause significant mounding during injections, and allow additional distribution of dissolved organic carbon and anaerobic conditions over the active lifetime of the EVO. In addition, it is preferred to limit the lateral distribution of the injected emulsion, and this is considered in the injection volume target. Based on this injection volume range, and the estimated total mass of EVO specified in Appendix F, EVO solutions shipped to the site (typically 60% EVO by weight in 260 gallon totes) will be diluted with water to the desired dosage to attain both the carbon loading and injection volume objectives.

f. Health and Safety and Site Security

A site-specific health and safety plan (HASP) will be prepared for the Demonstration Test to address safety precautions related to storage and handling the selected amendments, pressurized injection, and heavy equipment operation. In addition, the HASP will identify chemicals to be brought to the Site for use for groundwater treatment. The drilling/injection

subcontractor will be required to prepare their own site-specific HASP to be furnished to the Engineer. The subcontractor's HASP will include a spill prevention and response plan to detail precaution and response measures. In addition, AECOM will prepare and submit a site-specific HASP for its staff providing oversight and other site visitors.

Appropriate security measures will be erected (temporary chain-link fence, lockable conex box, and/or similar) for the periods of field activities (drilling, injections) to prevent trespassing and vandalism. For site workers, exclusion zones will be established using caution tape, cones, and/or jersey barriers around the bulk storage area, the dilution and batching area, and active injection points. All workers near active injections will be required to wear appropriate personal protective equipment, including but not limited to eye-protection and high visibility vests. Traffic cones will be used to protect workers from traffic. Police detail will be required when working within high-traffic areas.

Prior to commencing any drilling or direct-push activities, Dig Safe notifications, and additional underground utility clearance will be conducted, if necessary. All known subsurface utilities will be fully marked with paint, flagging, and/or cones. Utility maps will be consulted and additional private underground utility mark out and/or clearance will be conducted, if necessary. To prevent damage to subsurface utilities pre-clearing will be performed to a depth of at least five feet for all boreholes, with the pre-cleared hole to have a diameter larger than the driller's subsurface equipment.

g. Field Injection Activities

Two phases of injection are proposed for completion of the Demonstration Test. An initial injection test would be performed using a small number of injection points at the test sites (one to five injection points). The injection 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 crossgradient as a result of injection. Based on the results of the initial injection test, the design and implementation plan for the larger (more EVO application points) Demonstration Test will be adjusted. This monitoring and additional monitoring over time will be used to confirm the EVO is stable after injection. A description of how the field injection activities are anticipated to be conducted is provided below.

The EVO amendment will be shipped to the site as a liquid and will be stored in drums, totes, or other vendor supplied containers. The EVO containers will be stored inside a storage container or other protective structure.

An injection system for preparation, mixing, and injection of substrate solutions will consist of mixing tanks, mixers, pumps, piping, meters, valves, and fittings. All components will be selected from materials that are compatible for use with the selected amendments. Injection batches would be prepared by adding appropriate quantities of water to achieve the selected dilution concentration. It is anticipated that no hard pipe or trenching will be used between the solution mixing station and the injection point, and that mobile above-ground, hoses will be used to convey remedial solutions directly to the injection points. A manifold would likely be employed to inject into multiple injection wells simultaneously. Flow totalizers, pressure gauges, and shut-off valves will be included on each active injection leg connected to an injection point to monitor injection pressure, flow rates, and total volume added to each point. All systems would be leak-checked daily prior to injection by pressurizing the system with water to prevent spills from the injection system.

At each injection point, a direct-push drill rig will advance injection tooling to a targeted depth. Injection tooling can consist of a specialized injection tip, a screened interval, or similar device. A pre-determined volume will be injected at a targeted depth (or discrete depth interval), and then the injection tip will be advanced to the subsequent injection target depth (generally two to four feet deeper), and the process is repeated. This method of direct-push injection is referred to as top-down injection; however, tooling to inject from deepest depth upward (bottom-up) will also be mobilized, as the method that works best varies by site. To the extent practical, injections of EVO will be performed at low pressures (less than 10 pounds per square inch [PSI]); however, higher injection pressures may be required for injecting a deeper depths proposed for the PRBs. Based on AECOM in-situ remediation experience with the selected amendments and working in similar soil types, it is estimated that the injection flow rates will range from 2 to 5 gallons per minute at each point. To minimize mounding and improve delivery, injection will generally not be performed at adjacent points at the same time. A field log will be maintained to record the solution composition, the volume of solution delivered into each injection well, the length of time required for injection, and the injection pressure.

Electricity to power remediation equipment may be provided by a gasoline-powered generator. Potable water for batching and injection may be provided by tanker truck or from a nearby hydrant. Prior to commencing injections the potable water source will be identified, and laboratory analysis may be performed for nitrates.

7. PRB Demonstration Test Performance 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. This section details the performance monitoring program.

a. Groundwater samples will be collected from both existing monitoring wells (installed for initial characterization) and additional monitoring wells to be installed prior to installation of the Demonstration Test PRB. The monitoring well network for Demonstration Test performance monitoring is presented on Figure 7-1 and Figure 7-2 for the Eldredge Park and landfill PRBs, respectively. The monitoring well network for Demonstration Test sites includes monitoring wells upgradient and downgradient of the PRB to evaluate changes to nitrate and groundwater quality based on PRB performance. Monitoring wells downgradient of the PRB will be located at various distances away from the PRB to assess distance of emulsion travel, extent of reducing conditions for denitrification away from the PRB, potential for metals mobilization, and groundwater flow velocity. Monitoring wells cross-gradient of the PRBs will also be included, and hydraulic conductivity will be estimated in the cross-gradient and select downgradient monitoring wells to evaluate if there is any observed reduction in aquifer permeability as a result of the injection of EVO.

   All performance monitoring wells will be constructed of two-inch schedule-40 PVC, with proposed screened intervals as shown on Table 7-1 and Table 7-2. New monitoring wells are anticipated to be installed using direct-push drill rigs, as this method was used to install monitoring wells near the PRB locations for characterization and was determined to be a cost-effective means of installing wells for collecting representative groundwater samples.

b. Sampling Method, Frequency, and Analyses

   Groundwater samples will be collected using a peristaltic pump, bladder pump or whale pump. 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. Samples will be collected after field water quality parameters stabilize, or after 30 minutes of purging if parameters do not stabilize sooner.

Groundwater samples will be collected prior to initiation of in-situ treatment to provide a comparative baseline to evaluate performance of the Demonstration Test. Baseline groundwater samples will be analyzed to determine pre-treatment concentrations of nitrate and other indicator parameters whose change will be indicative of the impact of Demonstration Test treatment processes.

The wells anticipated to be sampled as part of PRB Demonstration at the Landfill and Eldredge Park are presented on Table 7-1 and Table 7-2, respectively. In addition, a synoptic water level event will be conducted after additional monitoring wells are installed but prior to the start of Demonstration Test injections to further assess groundwater direction and gradient. The first baseline sampling event would be completed prior to the initial injection 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:

1) Demonstrate reduction in nitrate concentrations in groundwater in monitoring wells compared to baseline samples and/or wells upgradient of the PRB;

2) Identify distance traveled by EVO emulsion;

3) Identify extent of generated reducing conditions;

4) Evaluate potential for reduction in aquifer permeability as a result of EVO application;

5) Evaluate persistence of EVO emulsion and anaerobic conditions favorable for denitrifying bacteria after PRB installation; and

6) Assess changes in groundwater monitoring parameters as a result of the PRB.

As a result of the generation of reducing conditions in groundwater, temporary mobilization of some metals native to the aquifer material may result. Laboratory analysis of select metals will be conducted as part of performance monitoring in select wells. Table 7-3 presents the monitoring parameters for the Demonstration Test performance monitoring. An overview of the Demonstration Test performance monitoring analyses and relevant to the PRB Demonstration Test sampling is shown below.

Table 7-3 Summary of Analyses for Groundwater Performance Evaluation

Parameter	Relevance to PRB Demonstration Test
Nitrate	Primary groundwater compound targeted for treatment.
Nitrite	Intermediate nitrogen species from the aerobic nitrification of ammonia to nitrate.
Ammonia	Reduced inorganic nitrogen species that occurs in proximity of leach fields and landfills.
Total Nitrogen	Analyses provide a summation of all organic and inorganic nitrogen species in groundwater as a result of leachfields and landfill.
CENSUS-DNA (Denitrifying Bacteria)	Analyses quantify relative abundance of denitrifying bacteria.
Metals (Fe, Mn, As)	Mobility of metals can be impacted by groundwater geochemistry changes, notably pH and ORP.
DOC	DOC
Sulfate	Sulfate will decrease with generation of sufficiently anaerobic conditions favorable for sulfate-reducing bacteria.
pH	Denitrification optimal pH (6.0 and 8.5). Groundwater pH can decrease as a result of fermentation of injected carbon substrates.
ORP	ORP will decrease with generation of reducing conditions following injection of carbon substrate.
Chloride	Chloride concentrations are higher in salt water, and higher concentrations would indicate influence of salt water intrusion.
Alkalinity	Denitrification reactions generate alkalinity (3.57 mg of $CaCO_3$ for each mg of nitrate reduced).
Boron	Boron is present in laundry detergents and is an indicator of groundwater flow emanating from leachfields.

8. Schedule and Coordination

This section presents a summary of the sequence of the major activities to be conducted as part of the PRB Demonstration Test.

a. Baseline Groundwater Monitoring - Additional monitoring wells, as described in Section 7, will be installed. Monitoring wells will be surveyed, and groundwater elevations will be measured. One round of sampling for groundwater collection will be performed with samples sent to a laboratory for analysis of parameters identified in Section 7. Well installation is anticipated to be completed in approximately two weeks. Groundwater well sampling will be completed in one to two weeks.

b. Initial Injection Test - Injections of EVO will be conducted at a small number of injection points at one or both of the two proposed sites (Eldredge Park and/or landfill). Injection tests will be conducted over approximately one week. Groundwater monitoring will be conducted for approximately four to six weeks to following the initial injection.

c. Final Design - Based on the results of the baseline groundwater monitoring and observations of the initial injection test the 100 percent design document for the Demonstration Test PRBs will be completed. It is anticipated that the final design will be completed three to four months after the initial injection test based on site-specific observations and if any major process changes are required from preliminary design.

d. Demonstration Test Injection - Drilling and injection subcontractor(s) will mobilize for implementing the injections for the Demonstration Test PRBs. It is anticipated that field work will occur over a period of one to two months based on AECOM experience injection on similar sites.

e. Demonstration Test Performance Monitoring - Following injection groundwater sampling to evaluate performance of the PRBs will be conducted. It is recommended to collect quarterly samples for a period of three years. Periodic reporting would be conducted to share results and observations with the Town, regulatory agencies, and the public.

f. Subcontractors - Multiple subcontractors will be required to implement the PRB Demonstration Test including:

1) Environmental Drilling – Drilling subcontractor(s) would install monitoring well and be utilized for direct-push drilling to support the injection of EVO;

2) Injection Subcontractor – This subcontractor will be tasked with handling, batching, and injecting EVO solutions into injection points per the design. The injection subcontractor may provide their own rigs for direct-push injection and/or may be the same firm as the drilling subcontractor;

3) Environmental Analytical Laboratory – A laboratory will be procured to complete all proposed chemical analysis of groundwater samples supporting the Demonstration Test; and

4) Reactive amendments (EVO) – The reactive amendments would be procured for the PRB Demonstration Test. The amendments can be procured by the injection subcontractor, the Engineer, or directly by the Town.

9. Waste Disposal

a. Demonstration Test field activities are anticipated to generate wastes requiring disposal, including purge water from monitoring well sampling, soil cuttings from well installation, and other wastes generated by PRB installation activities.

b. Well installation may generate soil cuttings. These cuttings will be placed into 55 gallon drums or a roll-off container. Each container will be labeled with the date of soil collection and the well bore hole where the cuttings were collected from. Soil samples will be collected for waste characterization, following which the soil will be disposed of at an approved disposal facility.

c. PRB Demonstration Test derived waste may consist of empty totes, empty bags, pallets, personal protective equipment, and miscellaneous trash. The empty totes/drums will be shipped back to the EVO manufacturer for re-use if possible. Other Demonstration Test derived waste can be disposed of as municipal trash.

10. Cost Estimate

Based on the evaluation contained within this Preliminary Engineering Work Plan for Permeable Reactive Barriers, cost estimates were prepared for Demonstration Tests and potential full-scale PRBs at the two preferred locations: Eldredge Park and Town Landfill.

Demonstration Test

Location	Eldredge Park	Town Landfill
PRB Length	200 feet	50 feet
Construction Costs[1]	$352,500	$97,100
Contingency (30%)	$88,100	$24,300
Total Construction	$440,600	$121,400
Town Administration and Engineering	$154,200	$42,500
Total Capital Cost	**$594,800**	**$163,900**
Annual O&M Cost[2]	$0	$0
Annual Replacement Costs[3]	$17,000	$8,700
Annual Monitoring and Reporting	$244,300	$110,300

Full-Scale

Location	Eldredge Park	Town Landfill
PRB Length	3,500 feet	550 feet
Construction Costs[1]	$1,739,100	$311,700
Contingency (30%)	$434,800	$77,900
Total Construction	$2,173,900	$389,600
Town Administration and Engineering	$760,900	$136,400
Total Capital Cost	**$2,934,800**	**$526,000**
Annual O&M Cost[2]	$0	$0
Annual Replacement Costs[3]	$25,700	$8,700
Annual Monitoring and Reporting[4]	$433,700	$117,500

Notes:

1. PRB construction costs include monitoring well installation labor and equipment, baseline groundwater sampling, emulsified vegetable oil, injection labor and equipment, and associated mobilization/demobilization costs.
2. No O&M costs are associated with PRBs.
3. Annual replacements associated with repairing/replacing monitoring wells that are damaged (15% of wells per year for Demonstration Test and 10% for full-scale). Cost presented includes construction, contingency, and administrative and engineering costs.
4. Annual Monitoring and Reporting consists of quarterly groundwater sampling to be performed by Engineer (labor, equipment, analytical costs), a quarterly groundwater sampling report, and an annual groundwater monitoring summary report.

To support evaluation of PRB costs and comparison with other nitrogen removal technologies a cost per mass nitrogen removed was generated for the full-scale scenario at the preferred location at Eldredge Park. Cost per nitrogen removed is presented below for initial construction as well as 20 year treatment time frame using the average nitrogen flux calculated for an Eldredge Park PRB. Calculations for nitrogen mass flux and cost per nitrogen removal are presented in Appendix G. The average nitrogen mass flux assumed a length of 3,500 feet and a vertical treatment interval of 40 feet and incorporated a groundwater seepage velocity of 1.5 feet per day and porosity of 0.3 based on observations for fine to coarse and in Orleans and on Cape Cod and a nitrate concentration of 5 mg/L. Sensitivity was incorporated for PRB rejuvenation frequency (every 3 years, every 5 years, and every 7 years), and monitoring of demonstration test and full-scale implementation will provide more data to assess frequency of rejuvenation.

Eldredge Park Full-Scale PRB (3,500 ft)	Rejuvenation Frequency		
Years	3	5	7
Average Annual PRB Nitrate Flux	3,256 kg/yr		
PRB Nitrate Flux (20 years)	65,110 kg		
Full Scale PRB Initial Construction	$2,940,000		
Full Scale PRB Monitoring Cost (20 years)	$8,680,000	$8,680,000	$8,680,000
Full Scale PRB Replacement Cost (20 years)	$490,000	$490,000	$490,000
Rejuvenation Events for 20 years	6	3	2
Full Scale PRB Cost for Rejuvenation (20 years)	$14,070,000	$7,035,000	$4,690,000
Full Scale PRB Total Cost (20 years)	$26,180,000	$19,145,000	$16,800,000
Full Scale PRB Nitrogen Removal Cost (20 year operations) ($/kg)	$402	$294	$258

Supporting calculations are provided in Attachment G.

11. References

Ahmad, F., McGuire, T.M., Lee, R.S., Becvar, E. - Considerations for the Design of Organic Mulch Permeable Reactive Barriers. Remediation, Winter 2007

Cape Cod Commission - Cape Code Regional Wastewater Management Plan Technology Assessment – Conventional Infrastructure, March 2013.

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Pinter and Associates (Pinter) - Groundwater Denitrification Using a Permeable Reactive Barrier. Canadian Consulting Engineering Awards, 2014 http://www2.canadianconsultingengineer.com/awards/pdfs/2014/D2_GroundwaterDenitrificationBarrier.pdf

Terra Systems - Personal communications with Michael Lee, PhD, 2016

12. List of Appendices

Appendix A - Technical Memorandum on Site Characterization and Evaluation for PRBs

Appendix B - Soil Boring Logs and Monitoring Well Coordinates

Appendix C - Select AECOM Experience with Anaerobic Bioremediation and Nitrate Reduction

Appendix D - MassDEP Underground Injection Control Registration DRAFT Permit Application (Form BRP WS 06)

Appendix E- Emulsified Vegetable Oil Product Information and Material Safety Data Sheet

Appendix F - Environmental Security Technology Certification Program – Supporting Calculations for EVO Amendment Dosages

Appendix G - Nitrogen Mass Flux and Nitrogen Removal Cost Calculations

Appendix H - Analytical Laboratory Reports

Tables

Table 1 Orleans Monitoring Well Construction Details

Location	Surface Elevation (ft)	TOC Elevation (ft)	Total Well Depth (ft bgs)	Screen Beginning Depth (ft bgs)	Screen End Depth (ft bgs)	Top Screen Elevation (ft)	Bottom Screen Elevation (ft)	Mid-Screen Elevation (ft)	Screen Length (ft)	Inst. Date	Address
MW-A1-A	15.2	14.71	40.0	30.0	40.0	-14.80	-24.80	-19.80	10.0	1/20/2016	82 Main Street
MW-A1-B	15.1	14.64	30.0	20.0	30.0	-4.90	-14.90	-9.90	10.0	1/20/2016	82 Main Street
MW-A1-C	14.8	14.76	20.0	10.0	20.0	4.80	-5.20	-0.20	10.0	1/20/2016	82 Main Street
MW-A3-A	34.8	34.47	56.0	46.0	56.0	-11.20	-21.20	-16.20	10.0	1/19/2016	Library
MW-A3-B	34.8	34.49	46.0	36.0	46.0	-1.20	-11.20	-6.20	10.0	1/19/2016	Library
MW-A3-C	35.0	35.71	36.0	26.0	36.0	9.00	-1.00	4.00	10.0	1/19/2016	Library
MW-E6-A	71.7	71.17	75.0	65.0	75.0	6.70	-3.30	1.70	10.0	1/21/2016	Landfill
MW-E6-B	71.8	71.36	65.0	55.0	65.0	16.80	6.80	11.80	10.0	1/21/2016	Landfill
MW-E6-C	71.9	71.50	62.0	52.0	62.0	19.90	9.90	14.90	10.0	1/21/2016	Landfill
MW-G1-A	26.5	26.31	45.0	35.0	45.0	-8.50	-18.50	-13.50	10.0	1/20/2016	Asas Landing
MW-G1-B	26.4	25.99	35.0	25.0	35.0	1.40	-8.60	-3.60	10.0	1/20/2016	Asas Landing

Notes: TOC = Top of Casing
bgs = below ground surface

Table 2 Orleans Groundwater Elevations

Well ID	Location	Date	TOC Elevation (ft)	Depth to Water (ft)	GW Elevation (ft)
MW-A1-A	82 Main Street	2/3/2016	14.71	7.70	7.01
MW-A1-B	82 Main Street	2/3/2016	14.64	7.80	6.84
MW-A1-C	82 Main Street	2/3/2016	14.46	7.44	7.02
MW-A3-A	Snow Library	2/4/2016	34.47	24.60	9.87
MW-A3-B	Snow Library	2/4/2016	34.49	24.65	9.84
MW-A3-C	Snow Library	2/4/2016	35.71	24.85	10.86
MW-E6-A	Landfill	2/10/2016	71.17	54.84	16.33
MW-E6-B	Landfill	2/10/2016	71.36	54.70	16.66
MW-E6-C	Landfill	2/10/2016	71.50	54.90	16.60
MW-2S (Landfill)[1]	Landfill	2/10/2016	101.51	86.65	14.86
MW-2D (Landfill)[1]	Landfill	2/10/2016	101.45	87.20	14.25
MW-5S (Landfill)[1]	Landfill	2/10/2016	103.93	88.80	15.13
MW-5D (Landfill)[1]	Landfill	2/10/2016	103.96	88.60	15.36
MW-1 (Landfill)[1]	Landfill	2/10/2016	85.08	69.30	15.78
MW-G1-A	Gibson Road	2/3/2016	26.31	23.20	3.11
MW-G1-B	Gibson Road	2/3/2016	25.99	22.95	3.04
MW-5 (PS)	Police Station	2/4/2016	40.74	29.64	11.10
MW-6 (PS)	Police Station	2/10/2016	44.77	33.45	11.32
MW-1 (PS)	Police Station	2/10/2016	45.68	33.50	12.18

Notes: 1. Field verification required to confirm orientation of the shallow and deep well locations for these monitoring wells pairs. Top of casing elevations recorded for each well during the March 2016 Survey.

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-A1-A**		**MW-A1-B**		**MW-A1-B (D)**		**MW-A1-C**	
Location	82 Main Street		82 Main Street		82 Main Street		82 Main Street	
Sampling Date	2/3/2016		2/3/2016		2/3/2016		2/3/2016	
Type of Sample	Sample		Sample		Duplicate		Sample	
Field Measurements								
pH (SU)	5.5		5.4		-		5.8	
Temperature (^{o}C)	11.0		11.0		-		10.4	
Dissolved Oxygen (DO; mg/L)	5.3		2.0		-		0.4	
Redox Potential (ORP; mV)	50.1		34.3		-		-280.0	
Conductivity (mS/cm)	271		217		-		642	
Laboratory Analyses								
Nitrogen								
Nitrate as N (mg/L)	**5.26**		**3.14**		**3.16**		**0.03**	
Nitrite as N (mg/L)	**0.05**		**0.02**		**0.018**		<0.01	
Ammonia (mg/L)	**0.1**		<0.1		<0.1		**0.22**	
Total Nitrogen (mg/L)	**5.31**		**3.41**		**3.18**		**0.6**	
Anions								
Chloride (mg/L)	**42.6**		**38.7**		**38.3**		**162**	
Sulfate (mg/L)	**6.2**		**6.5**		**6.6**		**22**	
Elements								
Dissolved Iron (mg/L)	<0.05		<0.05		**0.1**		**5.6**	
Dissolved Manganese (mg/L)	**0.2**		**0.4**		**0.5**		**0.5**	
Boron (mg/L)	**-**		<0.05		<0.05		**-**	
Dissolved Organic Carbon								
DOC (mg/L)	**-**		**0.6**		<0.05		**-**	

Notes:

NS - Not Sampled / NM-Not Measured

Bold - detected above the Minimum Detection Limit

D -Duplicate

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-A1-C**		**MW-A1-C (D)**		**MW-A3-A**		**MW-A3-B**	
Location	82 Main Street		82 Main Street		Library		Library	
Sampling Date	2/26/2016		2/26/2016		2/4/2016		2/4/2016	
Type of Sample	Sample		Duplicate		Sample		Sample	
Field Measurements								
pH (SU)	5.8		-		6.3		6.1	
Temperature (^{o}C)	9.2		-		13.0		13.2	
Dissolved Oxygen (DO; mg/L)	0.4		-		1.4		2.7	
Redox Potential (ORP; mV)	90.4		-		-165.7		-108.0	
Conductivity (mS/cm)	340		-		940		1058	
Laboratory Analyses								
Nitrogen								
Nitrate as N (mg/L)	**0.128**		**0.124**		**1.73**		**1.76**	
Nitrite as N (mg/L)	<0.01		<0.01		<0.044		<0.01	
Ammonia (mg/L)	**0.15**		**0.25**		**0.64**		**0.58**	
Total Nitrogen (mg/L)	**0.82**		**0.818**		**2.4**		**2.52**	
Anions								
Chloride (mg/L)	**72.4**		**72.8**		**321**		**361**	
Sulfate (mg/L)	<5		<5		**10.7**		**7.8**	
Elements								
Dissolved Iron (mg/L)	**-**		**-**		**12.9**		**12.2**	
Dissolved Manganese (mg/L)	**-**		**-**		**3.4**		**1.7**	
Boron (mg/L)	**-**		**-**		**-**		<0.05	
Dissolved Organic Carbon								
DOC (mg/L)	**4.11**		**4.84**		**-**		<0.5	

Notes:

NS - Not Sampled / NM-Not Measured

Bold - detected above the Minimum Detection Limit

D -Duplicate

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-A3-C**		**MW-E6-A**		**MW-E6-B**		**MW-E6-B (D)**	
Location	Library		Landfill		Landfill		Landfill	
Sampling Date	2/4/2016		2/10/2016		2/10/2016		2/10/2016	
Type of Sample	Sample		Sample		Sample		Duplicate	
Field Measurements								
pH (SU)	5.4		5.9		5.5		-	
Temperature (^{o}C)	13.4		13.3		12.5		-	
Dissolved Oxygen (DO; mg/L)	7.8		0.5		1.8		-	
Redox Potential (ORP; mV)	50.5		100.0		72.4		-	
Conductivity (mS/cm)	1522		672		847		-	
Laboratory Analyses								
Nitrogen								
Nitrate as N (mg/L)	**1.61**		**11.6**		**20.8**		**19.8**	
Nitrite as N (mg/L)	<0.01		<0.01		<0.01		<0.01	
Ammonia (mg/L)	<0.1		<0.1		<0.1		<0.1	
Total Nitrogen (mg/L)	**1.83**		**12.6**		**21.2**		**20.1**	
Anions								
Chloride (mg/L)	**597**		**143**		**115**		**118**	
Sulfate (mg/L)	**17.1**		**55.5**		**52.5**		**57**	
Elements								
Dissolved Iron (mg/L)	<0.05		**0.05**		**0.05**		<0.05	
Dissolved Manganese (mg/L)	**0.1**		**0.02**		**0.02**		**0.02**	
Boron (mg/L)	**-**		**0.141**		**0.141**		**0.125**	
Dissolved Organic Carbon								
DOC (mg/L)	**-**		**7.61**		**7.61**		**7.52**	

Notes:

NS - Not Sampled / NM-Not Measured

Bold - detected above the Minimum Detection Limit

D -Duplicate

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-E6-C**		**MW-2S (L)**		**MW-2D (L)**		**MW-5S (L)**	
Location	Landfill		Landfill		Landfill		Landfill	
Sampling Date	2/10/2016		2/26/2016		2/26/2016		2/26/2016	
Type of Sample	Sample		Sample		Sample		Sample	
Field Measurements								
pH (SU)	5.7		4.9		4.7		5.7	
Temperature (^{o}C)	13.2		13.2		12.4		13.5	
Dissolved Oxygen (DO; mg/L)	2.0		1.4		0.8		5.0	
Redox Potential (ORP; mV)	126.8		193.6		144.9		169.7	
Conductivity (mS/cm)	1046		942.0		886.0		477.0	
Laboratory Analyses								
Nitrogen								
Nitrate as N (mg/L)	**19**		**24.7**		**9.26**		**0.034**	
Nitrite as N (mg/L)	<0.01		<0.01		**0.065**		<0.01	
Ammonia (mg/L)	<0.1		**0.25**		**0.34**		<0.1	
Total Nitrogen (mg/L)	**19.8**		**27.1**		**11.1**		**1.78**	
Anions								
Chloride (mg/L)	**156**		**131**		**152**		**53.1**	
Sulfate (mg/L)	**56**		**66**		**51.6**		**27.9**	
Elements								
Dissolved Iron (mg/L)	<0.05		<0.1		<0.1		**-**	
Dissolved Manganese (mg/L)	**0.01**		**0.6**		**1.1**		**-**	
Boron (mg/L)	**0.14**		**0.223**		**0.156**		**-**	
Dissolved Organic Carbon								
DOC (mg/L)	**8.33**		**9.46**		**4.51**		**-**	

Notes:

NS - Not Sampled / NM-Not Measured

Bold - detected above the Minimum Detection Limit

D -Duplicate

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-5D (L)**		**MW-1 (L)**		**MW-G1-A**		**MW-G1-B**	
Location	Landfill		Landfill		Gibson Road		Gibson Road	
Sampling Date	2/26/2016		2/10/2016		2/3/2016		2/3/2016	
Type of Sample	Sample		Sample		Sample		Sample	
Field Measurements								
pH (SU)	6.1		NM		5.6		5.9	
Temperature (^{o}C)	13.5		NM		12.1		12.2	
Dissolved Oxygen (DO; mg/L)	2.4		NM		5.6		6.6	
Redox Potential (ORP; mV)	87.5		NM		49.5		1	
Conductivity (mS/cm)	437.0		NM		880		1027	
Laboratory Analyses								
Nitrogen								
Nitrate as N (mg/L)	**11.4**		NM		**0.885**		**0.444**	
Nitrite as N (mg/L)	<0.01		NM		<0.01		<0.01	
Ammonia (mg/L)	**15.3**		NM		<0.1		<0.1	
Total Nitrogen (mg/L)	**26.8**		NM		**1.13**		**0.44**	
Anions								
Chloride (mg/L)	**61.2**		NM		**233**		**283**	
Sulfate (mg/L)	**45.2**		NM		**13.3**		**10.2**	
Elements								
Dissolved Iron (mg/L)	**-**		NM		**0.06**		**0.1**	
Dissolved Manganese (mg/L)	**-**		NM		**0.08**		**0.4**	
Boron (mg/L)	**-**		NM		<0.05		**-**	
Dissolved Organic Carbon								
DOC (mg/L)	**-**		NM		<0.5		**-**	

Notes:

NS - Not Sampled / NM-Not Measured

Bold - detected above the Minimum Detection Limit

D -Duplicate

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-5 (PS)**		**MW-6 (PS)**		**MW-1 (PS)**	
Location	Police Station		Police Station		Police Station	
Sampling Date	2/4/2016		2/10/2016		2/10/2016	
Type of Sample	Sample		Sample		Sample	
Field Measurements						
pH (SU)	5.0		5.5		5.7	
Temperature (^{o}C)	12.2		13.1		13.2	
Dissolved Oxygen (DO; mg/L)	8.5		7.8		1.4	
Redox Potential (ORP; mV)	141.7		133.9		44.0	
Conductivity (mS/cm)	28		596		1107	
Laboratory Analyses						
Nitrogen						
Nitrate as N (mg/L)	**3.71**		**1.88**		**1.53**	
Nitrite as N (mg/L)	<0.01		<0.01		<0.01	
Ammonia (mg/L)	<0.1		<0.1		<0.1	
Total Nitrogen (mg/L)	**3.71**		**2.11**		**1.87**	
Anions						
Chloride (mg/L)	**86.7**		**114**		**292**	
Sulfate (mg/L)	**9.2**		**41**		<5	
Elements						
Dissolved Iron (mg/L)	<0.05		<0.05		**0.08**	
Dissolved Manganese (mg/L)	**0.08**		**0.02**		**0.04**	
Boron (mg/L)	**-**		<0.05		**-**	
Dissolved Organic Carbon						
DOC (mg/L)	**-**		**0.906**		**-**	

Notes:

NS - Not Sampled / NM-Not Measured

Bold - detected above the Minimum Detection Limit

D -Duplicate

TABLE 7-1
Non-Traditional Technologies - Permeable Reactive Barriers
Demonstration Test - Groundwater Sample Locations, Analyses, and Rationale

Monitoring Well ID/ Location	Depth to Water[1] (feet bgs)	Monitoring Well Screened Interval[2] (feet bgs)	Baseline Groundwater Analyses	Post-PRB (0.5 months)	Post-PRB (quarterly sampling for 3 years)	Rationale
Demonstration Test 2 - 200-foot Permeable Reactive Barrier Installed Near Eldredge Park (Site B)						
MW-BU2-C	*20*	*20 - 30*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Two multi-level monitoring well points with three screened intervals each. These sampling points will represent the upgradient conditions for the PRB Demonstration Test
MW-BU2-B	*20*	*30 - 40*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-BU2-A	*20*	*40 - 50*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-BU1-C	*20*	*20 - 30*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-BU1-B	*20*	*30 - 40*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-BU1-A	*20*	*40 - 50*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B1010-C	*20*	*20 - 30*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Three multi-level monitoring well points with three screened intervals will be monitored approximately 10 feet downgradient of the PRB. These sampling points will assess groundwater and nitrogen treatment immediately downgradient of the PRB, migration of carbon substrate (EVO), and evaluate distribution of dissolved organic carbon and denitrifying conditions
MW-B1010-B	*20*	*30 - 40*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B1010-A	*20*	*40 - 50*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B2010-C	*20*	*20 - 30*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B2010-B	*20*	*30 - 40*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B2010-A	*20*	*40 - 50*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B3010-C	*20*	*20 - 30*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B3010-B	*20*	*30 - 40*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B3010-A	*20*	*40 - 50*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	

TABLE 7-1
Non-Traditional Technologies - Permeable Reactive Barriers
Demonstration Test - Groundwater Sample Locations, Analyses, and Rationale

Monitoring Well ID/ Location	Depth to Water[1] (feet bgs)	Monitoring Well Screened Interval[2] (feet bgs)	Baseline Groundwater Analyses	Post-PRB (0.5 months)	Post-PRB (quarterly sampling for 3 years)	Rationale
MW-B1020-C	*20*	*20 - 30*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Three multi-level monitoring well points with three screened intervals will be monitored approximately 20 feet downgradient of the PRB. These sampling points will assess groundwater and nitrogen treatment immediately downgradient of the PRB, migration of carbon substrate (EVO), and evaluate distribution of dissolved organic carbon and denitrifying conditions
MW-B1020-B	*20*	*30 - 40*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B1020-A	*20*	*40 - 50*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B2020-C	*20*	*20 - 30*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B2020-B	*20*	*30 - 40*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B2020-A	*20*	*40 - 50*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B3020-C	*20*	*20 - 30*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B3020-B	*20*	*30 - 40*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B3020-A	*20*	*40 - 50*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B1050-C	*20*	*20 - 30*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Three multi-level monitoring well points with three screened intervals will be monitored approximately 50 feet downgradient of the PRB. These sampling points will assess groundwater and nitrogen treatment immediately downgradient of the PRB, migration of carbon substrate (EVO), and evaluate distribution of dissolved organic carbon and denitrifying conditions
MW-B1050-B	*20*	*30 - 40*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B1050-A	*20*	*40 - 50*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B2050-C	*20*	*20 - 30*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B2050-B	*20*	*30 - 40*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B2050-A	*20*	*40 - 50*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B3050-C	*20*	*20 - 30*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B3050-B	*20*	*30 - 40*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B3050-A	*20*	*40 - 50*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	

TABLE 7-1
Non-Traditional Technologies - Permeable Reactive Barriers
Demonstration Test - Groundwater Sample Locations, Analyses, and Rationale

Monitoring Well ID/ Location	Depth to Water[1] (feet bgs)	Monitoring Well Screened Interval[2] (feet bgs)	Baseline Groundwater Analyses	Post-PRB (0.5 months)	Post-PRB (quarterly sampling for 3 years)	Rationale
MW-B1100-C	*20*	*20 - 30*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Three multi-level monitoring well points with three screened intervals will be monitored approximately 100 feet downgradient of the PRB. These sampling points will assess groundwater and nitrogen treatment immediately downgradient of the PRB, migration of carbon substrate (EVO), and evaluate distribution of dissolved organic carbon and denitrifying conditions
MW-B1100-B	*20*	*30 - 40*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B1100-A	*20*	*40 - 50*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B2100-C	*20*	*20 - 30*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B2100-B	*20*	*30 - 40*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B2100-A	*20*	*40 - 50*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B3100-C	*20*	*20 - 30*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B3100-B	*20*	*30 - 40*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B3100-A	*20*	*40 - 50*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B2175-C	*20*	*20 - 30*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	A multi-level monitoring well point on one transect with three screened intervals will be monitored approximately 175 feet downgradient of the PRB. These sampling points will assess groundwater and nitrogen treatment immediately downgradient of the PRB, migration of carbon substrate (EVO), and evaluate distribution of dissolved organic carbon and denitrifying conditions
MW-B2175-B	*20*	*30 - 40*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B2175-A	*20*	*40 - 50*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B1150-C	*20*	*20 - 30*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	A multi-level monitoring well point on one transect with three screened intervals will be monitored approximately 150 feet downgradient of the PRB. These sampling points will assess groundwater and nitrogen treatment immediately downgradient of the PRB, migration of carbon substrate (EVO), and evaluate distribution of dissolved organic carbon and denitrifying conditions
MW-B1150-B	*20*	*30 - 40*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-B1150-A	*20*	*40 - 50*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
TOTAL	48 wells		48	18	48	

TABLE 7-2
Non-Traditional Technologies - Permeable Reactive Barriers
Demonstration Test - Groundwater Sample Locations, Analyses, and Rationale

Monitoring Well ID/ Location	Depth to Water[1] (feet bgs)	Monitoring Well Screened Interval[2] (feet bgs)	Baseline Groundwater Analyses	Post-PRB (2, 7, 14 days)	Post-PRB (quarterly sampling for 3 years)	Rationale
Demonstration Test 1 - Focused Injection Test at the Landfill with 5 injection points to assess transport of carbon substrate and changes to groundwater chemistry						
MW-E6-C	55	45 - 55	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Multi-level monitoring well point with three screened intervals. This sampling point will represent the upgradient location for the focused PRB Demonstration Test
MW-E6-B	55	55 - 65	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-E6-A	55	65 - 75	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-E1005-C	*45*	*45 - 55*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Visual Observation, Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Multi-level monitoring well point with three screened intervals. This sampling point will be located approximately 5 feet downgradient of PRB injection points to assess groundwater and nitrogen treatment immediately downgradient of the PRB and evaluate migration of carbon substrate (EVO)
MW-E1005-B	*45*	*55 - 65*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Visual Observation, Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-E1005-A	*45*	*65 - 75*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Visual Observation, Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-E1010-C	*45*	*45 - 55*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Visual Observation, Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Two multi-level monitoring well points with three screened intervals will be monitored approximately 10-15 feet downgradient of the PRB. These sampling points will assess groundwater and nitrogen treatment immediately downgradient of the PRB, migration of carbon substrate (EVO), and evaluate distribution of dissolved organic carbon and denitrifying conditions
MW-E1010-B	*45*	*55 - 65*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Visual Observation, Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-E1010-A	*45*	*65 - 75*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Visual Observation, Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-E1015-C	*45*	*45 - 55*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Visual Observation, Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-E1015-B	*45*	*55 - 65*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Visual Observation, Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-E1015-A	*45*	*65 - 75*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Visual Observation, Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-E1020-C	*45*	*45 - 55*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Visual Observation, Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Multi-level monitoring well point with three screened intervals. This sampling point will be located approximately 20 feet downgradient of PRB injection points to assess groundwater and nitrogen treatment downgradient of the PRB and evaluate distribution of dissolved organic carbon and denitrifying conditions
MW-E1020-B	*45*	*55 - 65*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Visual Observation, Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-E1020-A	*45*	*65 - 75*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Visual Observation, Total Nitrogen, Nitrate Nitrogen, Dissolved Organic Carbon	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-E1050-C	*45*	*45 - 55*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Multi-level monitoring well point with three screened intervals. This sampling point will be located approximately 50 feet downgradient of PRB injection points to assess groundwater and nitrogen treatment downgradient of the PRB and evaluate distribution of dissolved organic carbon and denitrifying conditions
MW-E1050-B	*45*	*55 - 65*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-E1050-A	*45*	*65 - 75*	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	

TABLE 7-2
Non-Traditional Technologies - Permeable Reactive Barriers
Demonstration Test - Groundwater Sample Locations, Analyses, and Rationale

Monitoring Well ID/ Location	Depth to Water[1] (feet bgs)	Monitoring Well Screened Interval[2] (feet bgs)	Baseline Groundwater Analyses	Post-PRB (2, 7, 14 days)	Post-PRB (quarterly sampling for 3 years)	Rationale
MW-2S	*75*		Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	Four existing monitoring wells (two pairs of multi-level wells) will be monitored as part of the Demonstration Test to assess any change in groundwater conditions at locations further downgradient of the PRB carbon substrate application. Data will be compared with sampling results dating back to 1994
MW-2D	*75*		Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-5S	*75*		Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
MW-5D	*75*		Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	--	Total Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Dissolved Metals, Sulfate, Dissolved Organic Carbon, Methane	
TOTAL	**22 wells**		**22**	**12**	**22**	

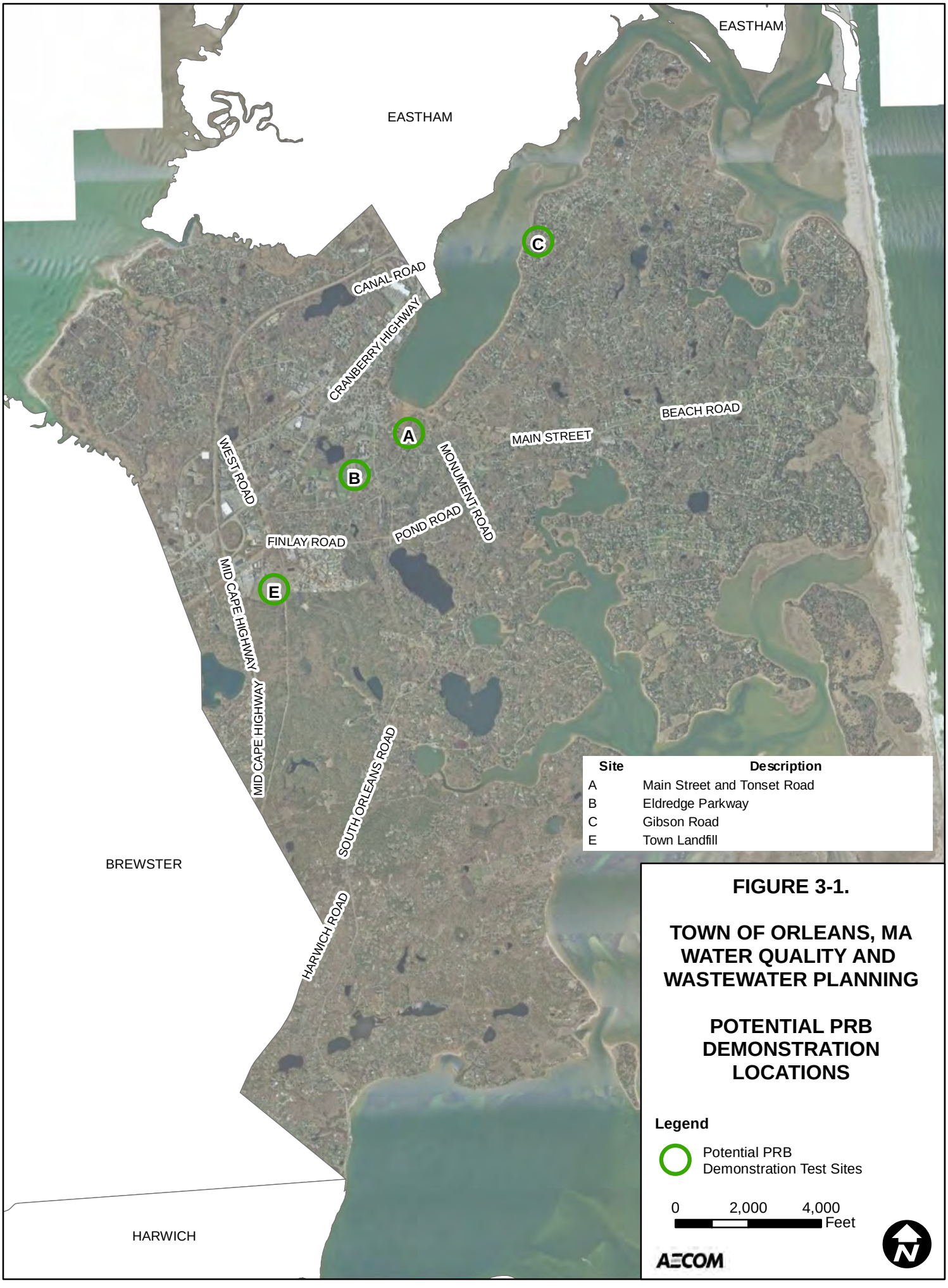
Notes:
bgs = Below Ground Surface
TBD - to be determined

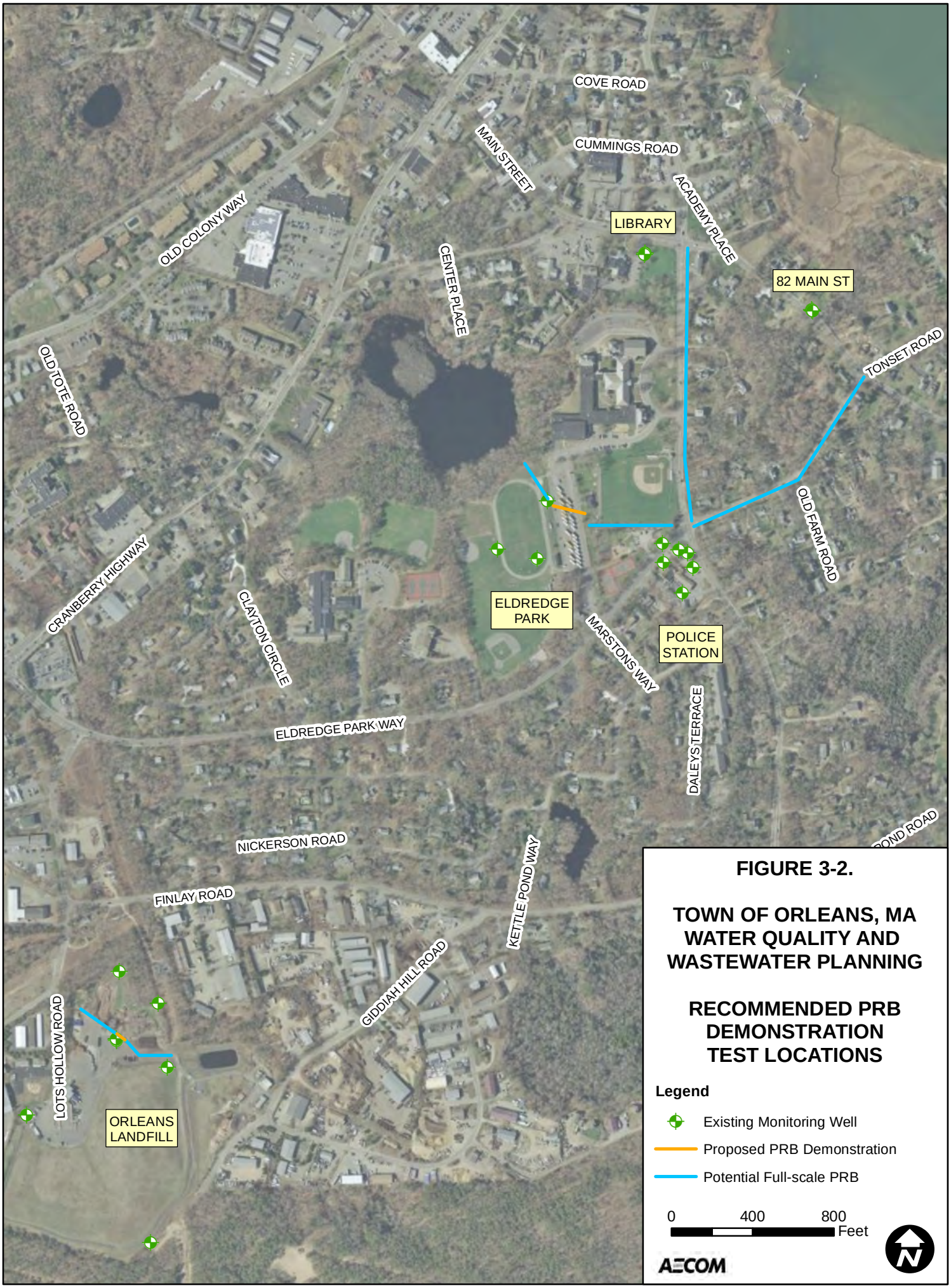
Dissolved Metals = Arsenic, Iron, Manganese

TOC = Total Organic Carbon

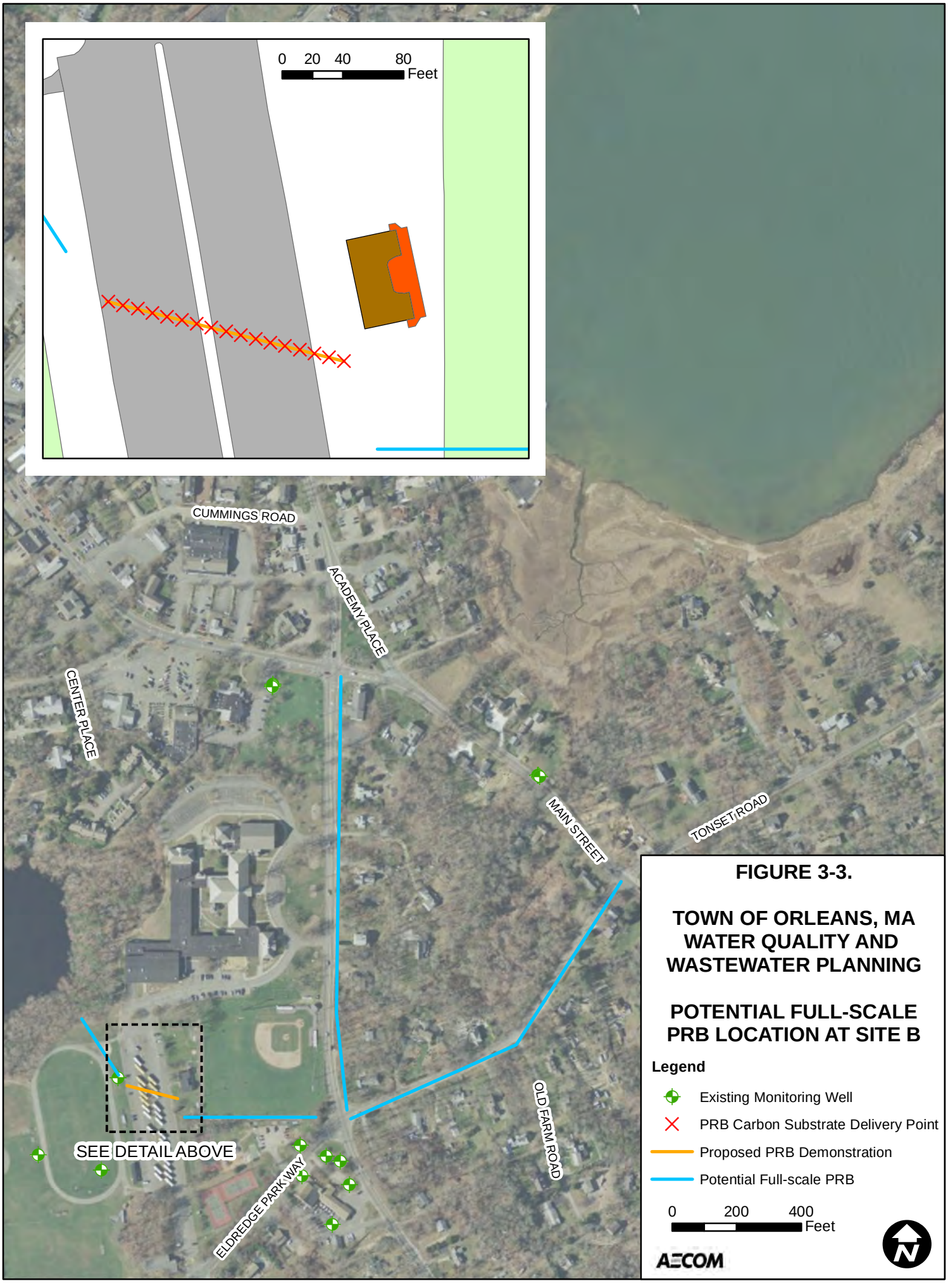
[1] - Depth to water, if estimated, shown in italics
2 - Well screen interval, if estimated, shown in italics
[3] - Field measurements will be recorded for temperature, dissolved oxygen, pH, oxidation reduction potential, specific conductivity, and turbidity for all samples.

Figures


EASTHAM
EASTHAM
C
CANAL ROAD
CRANBERRY HIGHWAY
BEACH ROAD
A
MAIN STREET
WEST ROAD
B
MONUMENT ROAD
POND ROAD
FINLAY ROAD
E
MID CAPE HIGHWAY
MID CAPE HIGHWAY
SOUTH ORLEANS ROAD
BREWSTER
HARWICH ROAD
HARWICH
Site
Description
A
Main Street and Tonset Road
B
Eldredge Parkway
C
Gibson Road
E
Town Landfill
FIGURE 3-1.
TOWN OF ORLEANS, MA
WATER QUALITY AND
WASTEWATER PLANNING
POTENTIAL PRB
DEMONSTRATION
LOCATIONS
Legend
Potential PRB
Demonstration Test Sites
0
2,000
4,000
Feet
AECOM
N
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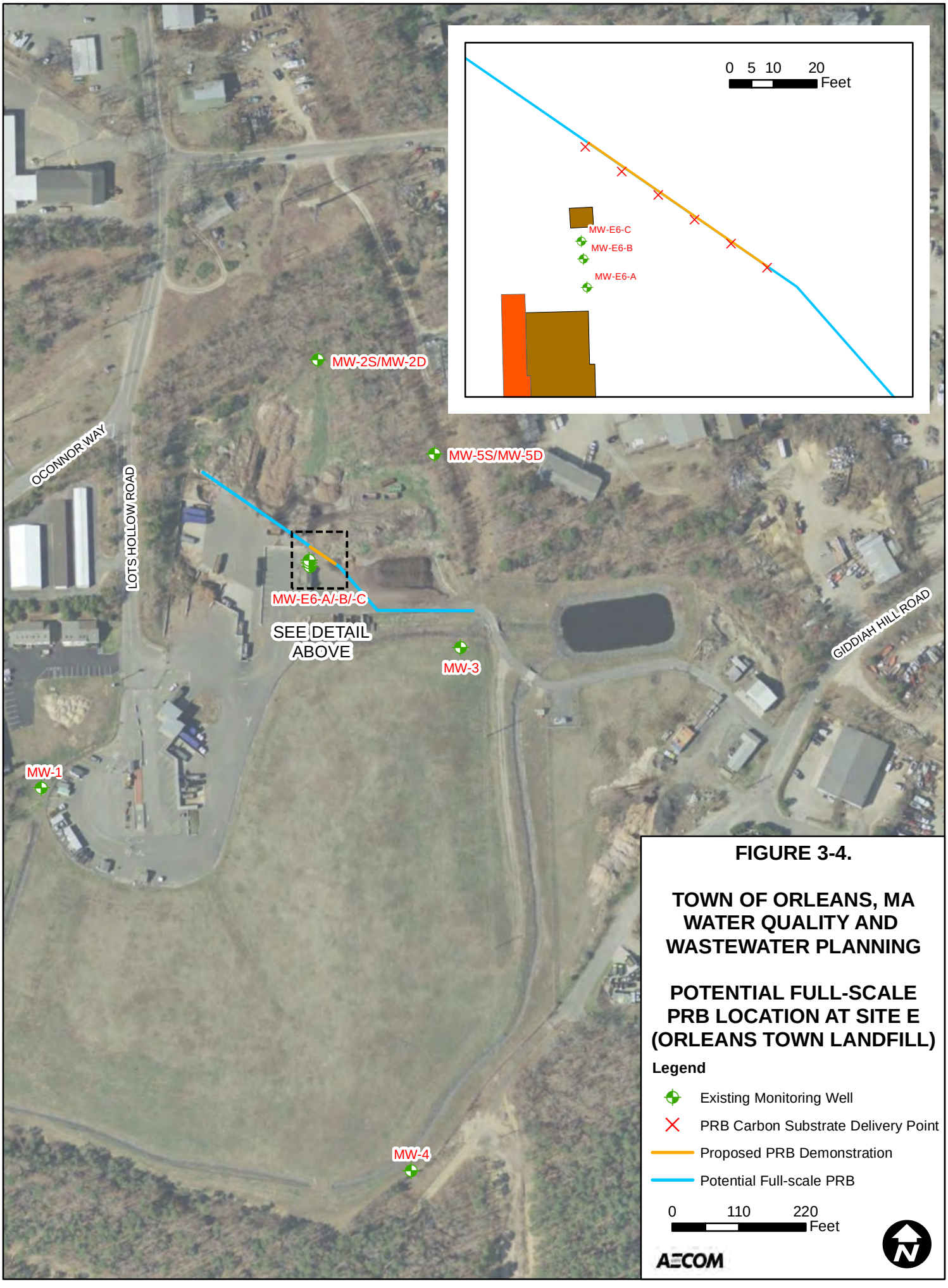


FIGURE 3-4.

TOWN OF ORLEANS, MA WATER QUALITY AND WASTEWATER PLANNING

POTENTIAL FULL-SCALE PRB LOCATION AT SITE E (ORLEANS TOWN LANDFILL)

Legend

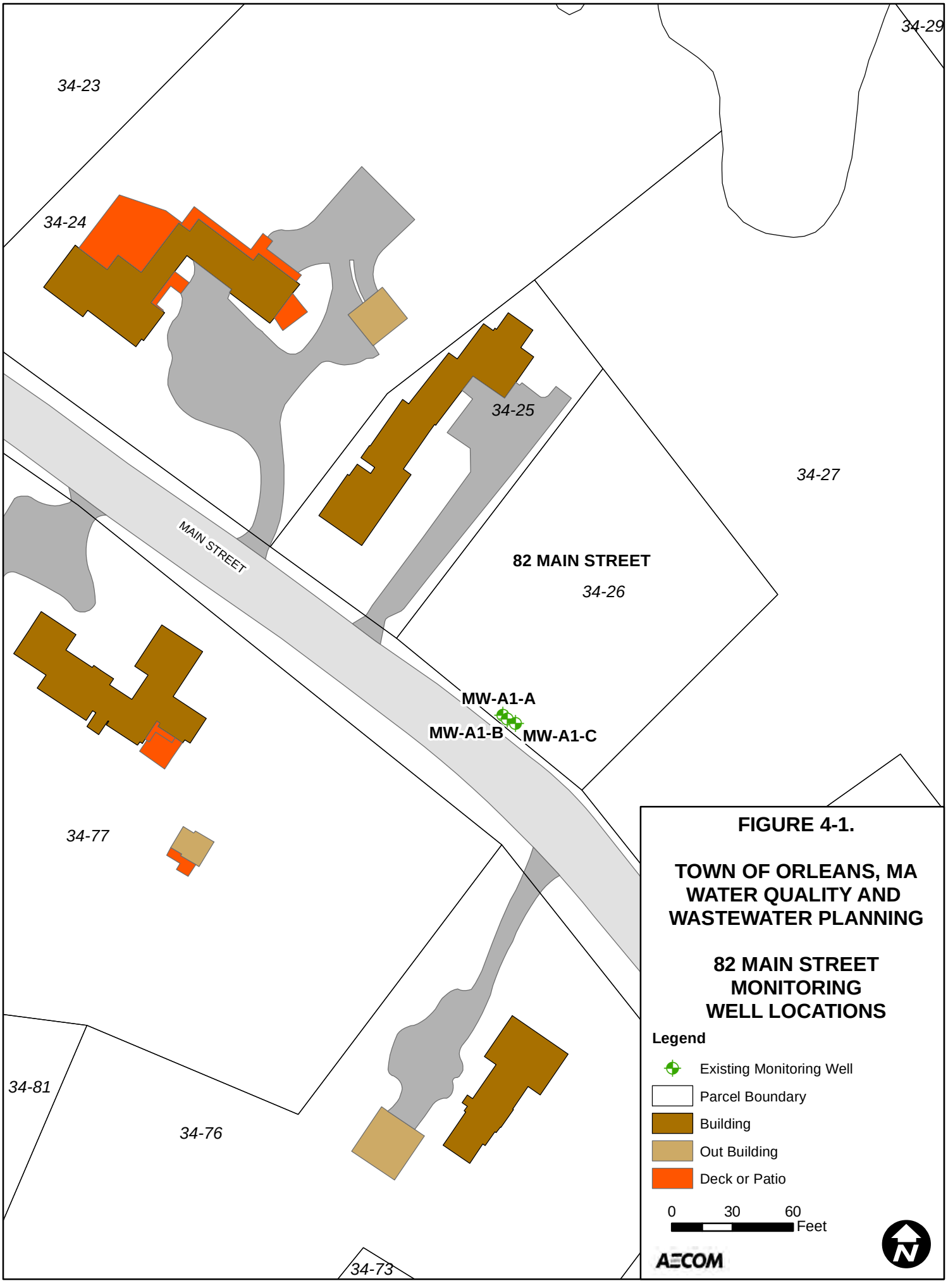
- Existing Monitoring Well
- PRB Carbon Substrate Delivery Point
- Proposed PRB Demonstration
- Potential Full-scale PRB

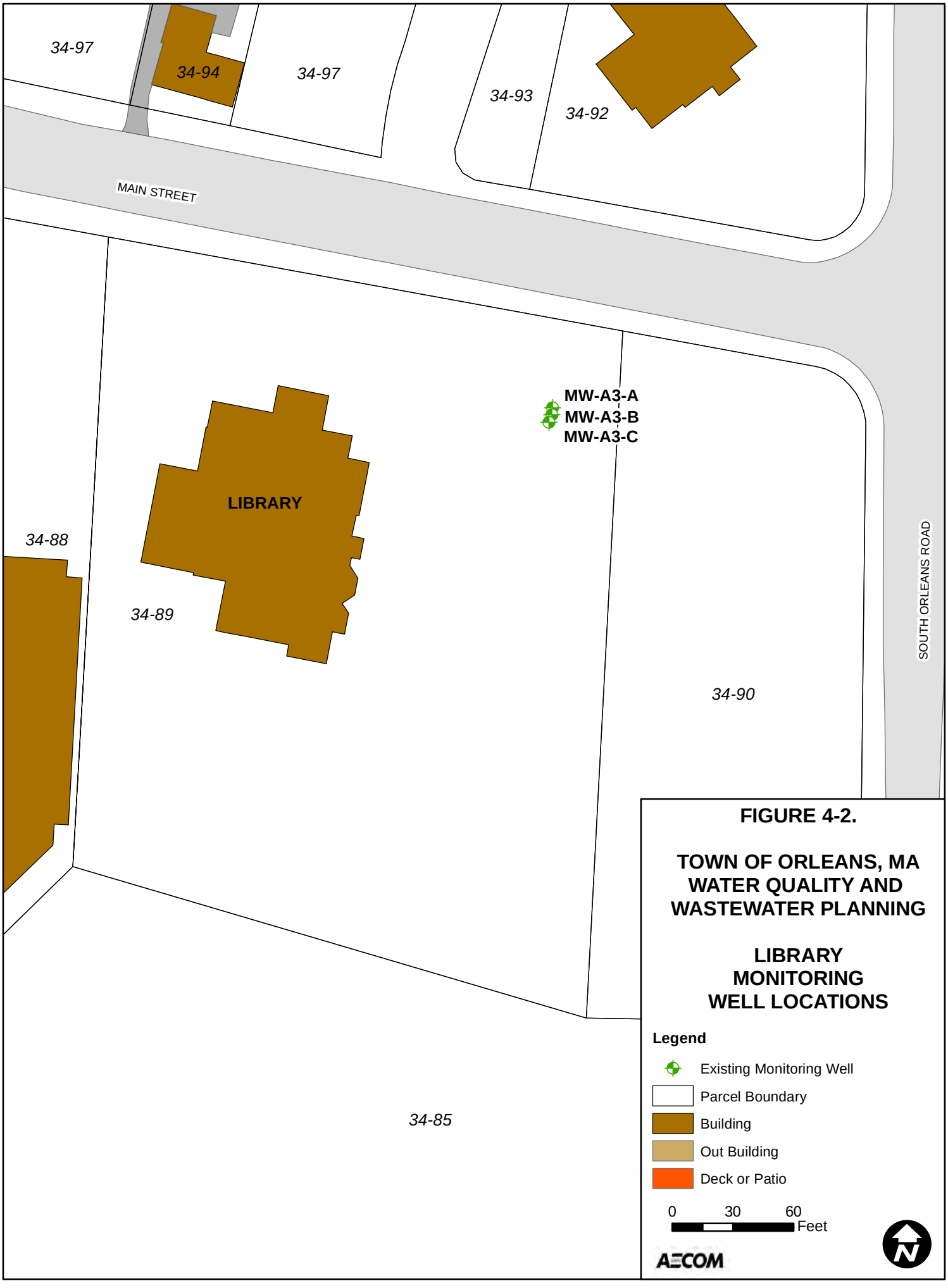
0 110 220 Feet

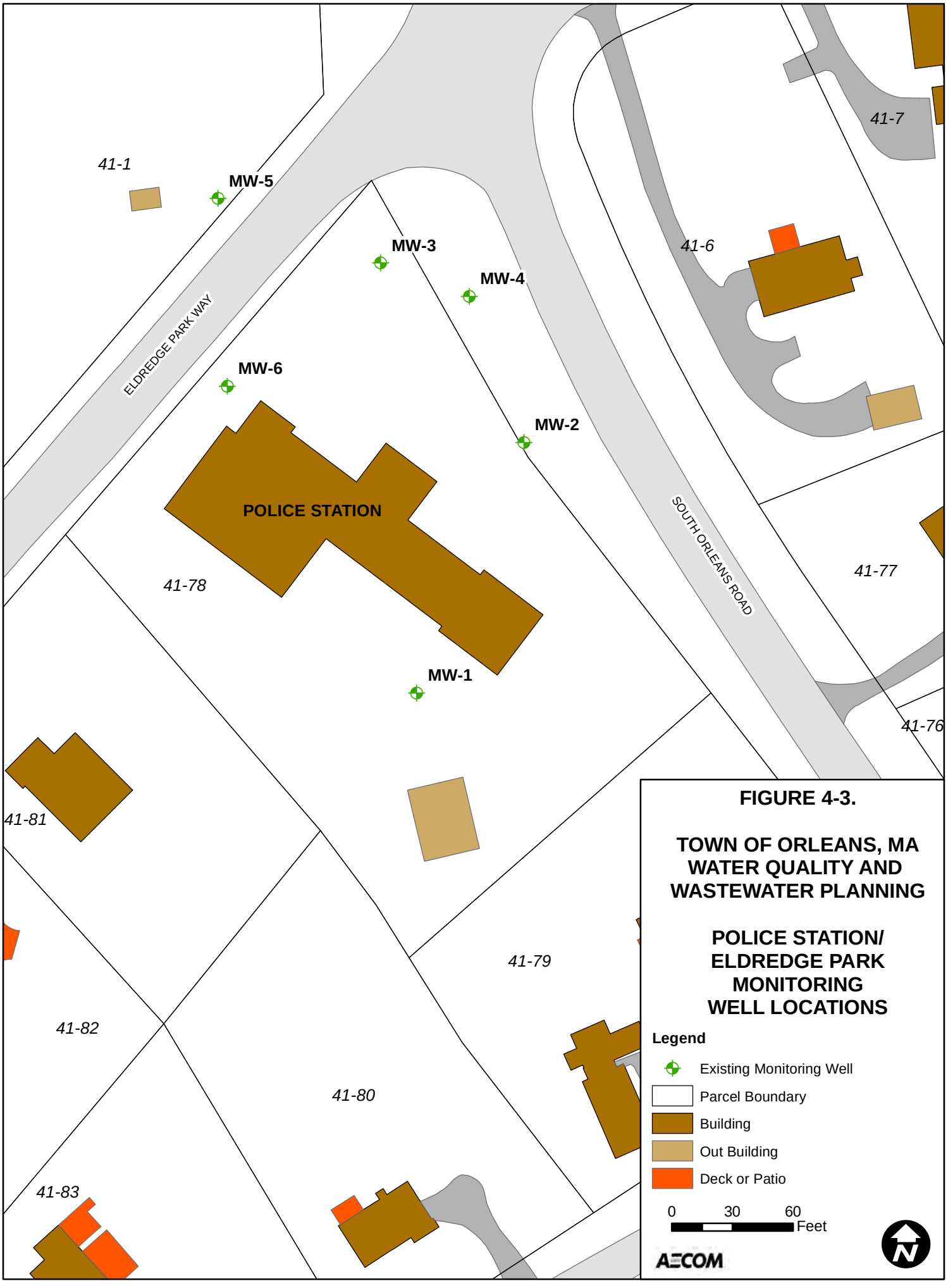
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34-23
34-29
34-24
34-25
34-27
MAIN STREET
82 MAIN STREET
34-26
MW-A1-A
MW-A1-B
MW-A1-C
34-77
34-81
34-76
34-73
FIGURE 4-1.
TOWN OF ORLEANS, MA
WATER QUALITY AND
WASTEWATER PLANNING
82 MAIN STREET
MONITORING
WELL LOCATIONS
Legend
Existing Monitoring Well
Parcel Boundary
Building
Out Building
Deck or Patio
0
30
60
Feet
AECOM
N
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34-97
34-94
34-97
34-93
34-92
MAIN STREET
MW-A3-A
MW-A3-B
MW-A3-C
LIBRARY
34-88
34-89
34-90
SOUTH ORLEANS ROAD
34-85
FIGURE 4-2.
TOWN OF ORLEANS, MA
WATER QUALITY AND
WASTEWATER PLANNING
LIBRARY
MONITORING
WELL LOCATIONS
Legend
Existing Monitoring Well
Parcel Boundary
Building
Out Building
Deck or Patio
0
30
60
Feet
AECOM
N
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41-1
MW-5
MW-3
MW-4
41-6
41-7
ELDREDGE PARK WAY
MW-6
MW-2
POLICE STATION
SOUTH ORLEANS ROAD
41-78
41-77
MW-1
41-76
41-81
41-79
41-82
41-80
41-83
FIGURE 4-3.
TOWN OF ORLEANS, MA
WATER QUALITY AND
WASTEWATER PLANNING
POLICE STATION/
ELDREDGE PARK
MONITORING
WELL LOCATIONS
Legend
Existing Monitoring Well
Parcel Boundary
Building
Out Building
Deck or Patio
0
30
60
Feet
AECOM
N
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11-6
11-66
11-5
11-3
11-67
11-4
11-68
ASAS LANDING
MW-G1-B
MW-G1-A
11-2
11-69
11-1
19-29
19-28
19-30
19-31
19-27
GIBSON ROAD
19-32
19-26
19-33
FIGURE 4-4.
TOWN OF ORLEANS, MA
WATER QUALITY AND
WASTEWATER PLANNING
GIBSON ROAD
MONITORING
WELL LOCATIONS
Legend
Existing Monitoring Well
Parcel Boundary
Building
Out Building
Deck or Patio
0
30
60
Feet
AECOM
N
G:\Projects\MUNI\60476644ORL\Maps\PRB_Figure4-4_GibsonRd.mxd

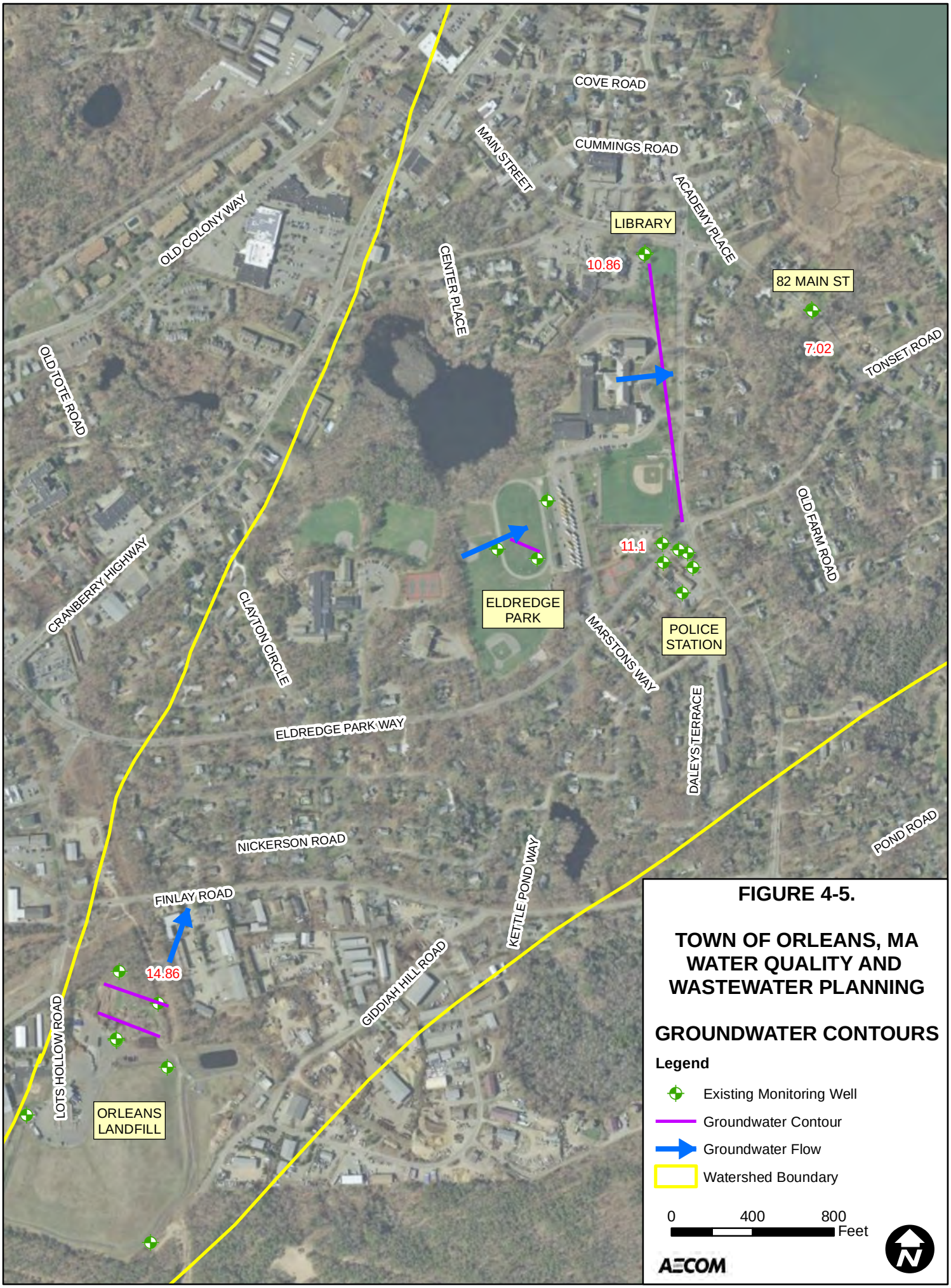


FIGURE 4-5.

TOWN OF ORLEANS, MA WATER QUALITY AND WASTEWATER PLANNING

GROUNDWATER CONTOURS

Legend

- Existing Monitoring Well
- Groundwater Contour
- Groundwater Flow
- Watershed Boundary

0 400 800 Feet

AECOM

N

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FIGURE 7-1.

TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING

PROPOSED PRB DEMONSTRATION LOCATION AT SITE B - ELDREDGE PARK

Legend

- Existing Monitoring Well
- Proposed PRB Monitoring Well
- Proposed Cross-Gradient Monitoring Well
- Proposed PRB Demonstration
- Potential Full-scale PRB
- PRB Carbon Substrate Delivery Point
- Pavement
- Building
- Out Building
- Deck or Patio

Notes:
1. Each monitoring well location assumes three discrete monitoring wells.
2. Cross-gradient monitoring wells are for hydraulic monitoring only.

0 25 50 Feet

AECOM

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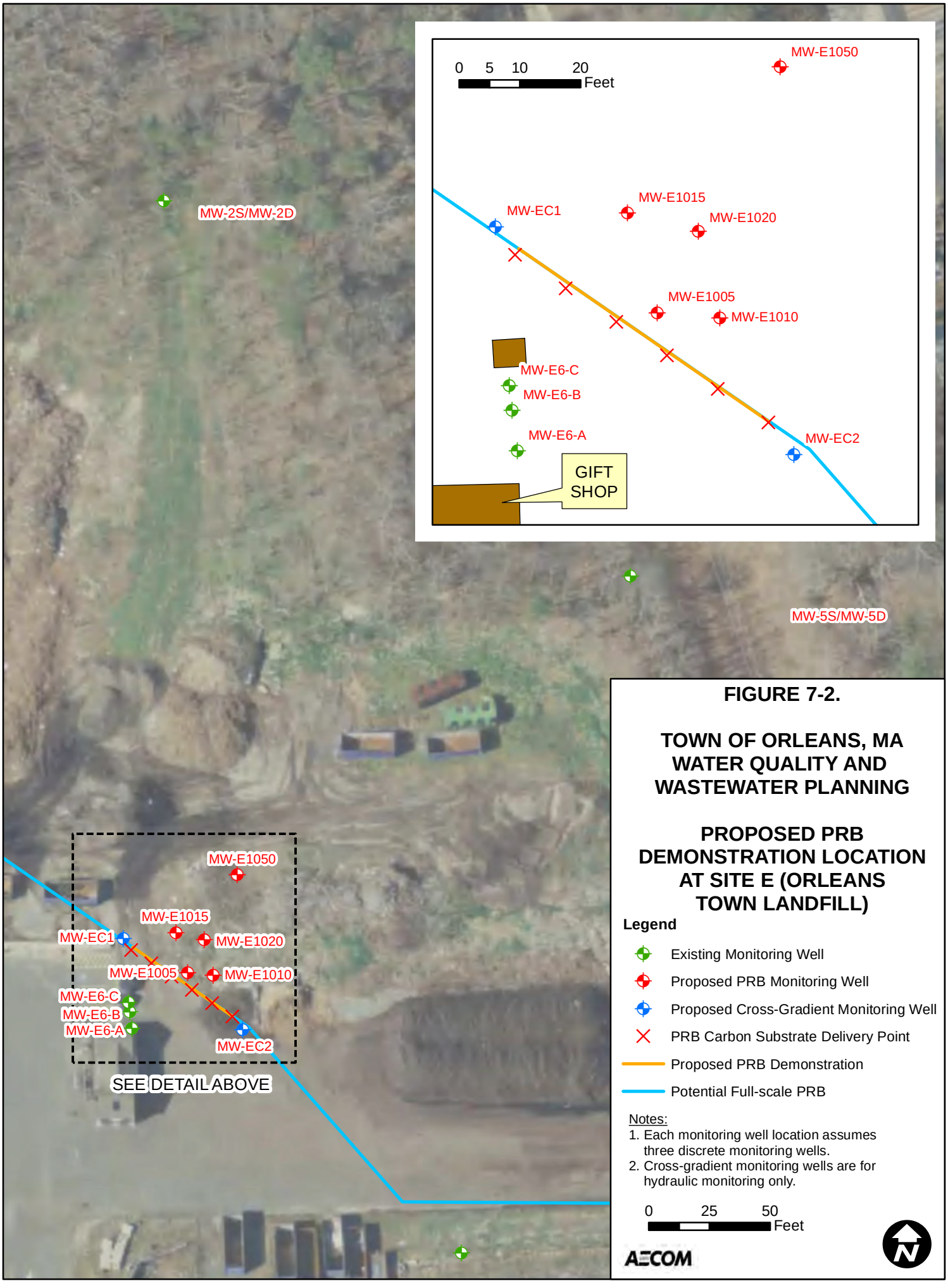


FIGURE 7-2.

TOWN OF ORLEANS, MA WATER QUALITY AND WASTEWATER PLANNING

PROPOSED PRB DEMONSTRATION LOCATION AT SITE E (ORLEANS TOWN LANDFILL)

Legend

- Existing Monitoring Well
- Proposed PRB Monitoring Well
- Proposed Cross-Gradient Monitoring Well
- PRB Carbon Substrate Delivery Point
- Proposed PRB Demonstration
- Potential Full-scale PRB

Notes:

1. Each monitoring well location assumes three discrete monitoring wells.
2. Cross-gradient monitoring wells are for hydraulic monitoring only.

0 25 50
Feet

AECOM

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Appendix A

Technical Memorandum on Site Characterization and Evaluation for Permeable Reactive Barriers

AECOM
9 Jonathan Bourne Drive
Pocasset, MA 02559
www.aecom.com

508.833.6950 tel
508.833.6951 fax

Memorandum

To	George Meservey, Director of Planning & Community Development Michael Domenica, PE, Program Manager
CC	Betsy Shreve, AICP, AECOM Project Director Paul Dombrowski, AECOM Mark Owen, AECOM Juli Marrion, AECOM James Begley, MT Environmental Restoration
Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 3 – NT Demonstration Projects** **Deliverable 3.c.5 - Final Technical Memorandum on Site Characterization and Evaluation for Permeable Reactive Barriers (evaluation criteria and ranking)**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	May 19, 2016

1. Background

This Technical Memorandum documents the process used to select locations for Permeable Reactive Barrier (PRB) Demonstration Testing. An objective assessment of potential locations, including use of a system to record rankings of sites based on established criteria, formed the basis for selection. The selected locations will be used to develop a Preliminary Engineering Work Plan, which will detail designs, schedules, and costs for PRB demonstrations. Strategies for performance verification through groundwater monitoring will be included in the Work Plan.

1) Key Terms

(1) Permeable Reactive Barrier (PRB) – consists of a zone of reactive material installed in the path of a dissolved contaminant (e.g., nitrate) plume.

(2) Denitrification – biological conversion of nitrate to inert nitrogen gas by naturally occurring bacteria.

(3) Reactive media (amendments) – material used to stimulate bacteria to transform nitrate to nitrogen gas.

(4) PRB Installation Methods

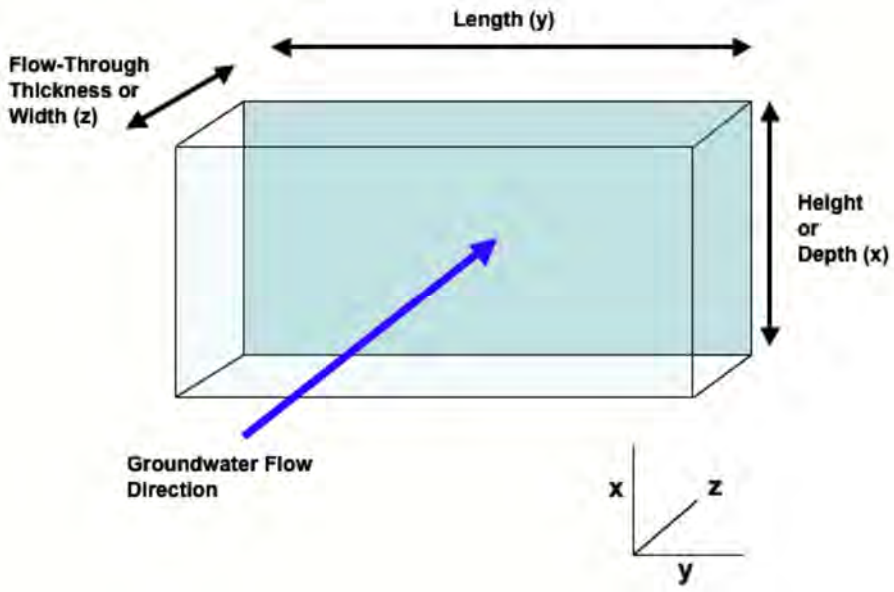
- excavating a long deep trench to place reactive solid material in the path of target groundwater,
- using soil boring and/or wells to inject a reactive liquid or emulsion in the path or target groundwater flow, and
- using soil borings and wells to place a solid reactive material in the path of target groundwater.

(5) Mass flux - a rate measurement of contaminant mass moving through a specific defined area, expressed as mass/time/area (e.g., kg/yr/m2).

(6) Mass discharge – the sum of mass flux across the plume and is therefore expressed as mass/time (e.g., kg/yr) – these are the same units used to express Total Maximum Daily Load (TMDL).

(7) Dimensions of a PRB – Length, height (depth) and flow through thickness.

(8) Hydraulic Capture Zone of the PRB – groundwater flow captured by the PRB from upgradient areas of the watershed.



From ITRC 2011

2. Introduction

AECOM is providing water quality and wastewater planning and engineering services to the Town of Orleans (the Town) to reduce excessive nitrogen discharges to the Town's ponds, estuaries and embayments. The Project represents the first to implement a "Hybrid" approach under the Cape Cod 208 Water Quality Plan, recently approved by both USEPA and MassDEP. The Project consists of conceptual and preliminary design to update the Comprehensive Wastewater Management Plan (CWMP) completed by the Town in 2011 to reflect the Consensus Plan (Water Quality Management Plan) developed by the Town in 2015. The Project goal is to minimize the proposed sewered footprint (area of Town and number of properties to be sewered) to the greatest extent possible by maximizing the use of several non-traditional technologies (Coastal Habitat Restoration, Aquaculture, Floating Constructed Wetlands, and PRBs). Figure 1 shows a version of the Consensus Plan Map (February 2015) showing anticipated locations of PRBs.

Major watersheds in the Town of Orleans include the Nauset Inlet, Pleasant Bay, Cape Cod Bay, and Atlantic Ocean watersheds. The groundwater system comprising these watersheds is part of the Monomoy Lens of the Cape Cod Aquifer (Walter et. al., 2004). Approximately 80% of the residential homes and many of the commercial businesses in Orleans are in the Nauset Inlet and Pleasant Bay watersheds (Wright-Pierce, 2010). These watersheds are characterized by numerous sub-watersheds contributing groundwater discharge to salt ponds and inlets. 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.

Removing nitrogen from groundwater can be mediated by naturally occurring denitrifying bacteria in the aquifer that gain energy from dissolved organic carbon or other food substrates and 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 nitrogen load removed by the PRB comes from water and wastewater recharged to the groundwater that contains nitrogen upgradient and within the hydraulic capture zone of the barrier.

The system is permeable because the food substrates and other amendments added do not interfere with groundwater flow, and nitrate is removed as groundwater passes through. A PRB would be most cost effective where groundwater transport of nitrogen is significant, with higher nitrate concentration and a relatively fast groundwater velocity, resulting in a high mass flux of nitrate through the treatment zone. It is this mass flux of nitrogen that contributes to nitrogen loading to downgradient surface waters and needs to be reduced.

There are several design concepts and variations for PRBs. Systems and amendments are engineered to optimize conditions for groundwater treatment within the PRB treatment zone depending on site conditions such as nitrate concentrations, groundwater chemistry, and groundwater velocity. PRB installation may be via trench excavation or soil boring. Trench systems typically utilize solid amendment media such as wood chips. Boring methods allow delivery of either liquid or solid amendments in the subsurface via direct placement or injection. There are also design concepts using soil borings to place electrodes for generation of amendments in the subsurface with electrochemical methods.

Trench installations require excavation to place the reactive substrate in the subsurface. Standard construction excavation equipment would not be capable of reaching targeted depths greater than 30 feet below grade. Nitrate plumes in the aquifer are expected to extend 30 feet or more below the water table and depth to the water table is variable from location to location. Trenching using a specialized one-pass trencher could go deeper, up to a total of approximately 40 to 50 feet below grade. The one-pass method cuts a trench with specialized large excavators that simultaneously backfill with the reactive materials through a delivery box that extends to the bottom of the trench. The trencher pulls this trench box along while a conveyor system keeps the box full of reactive material. Excavations must be located very close to or in natural resource areas adjacent to surface waters to possibly reach effective depths. Working in natural resource areas would increase permitting requirements and costs. Installation of trenches may also cause major disruption and abutter concerns may be significant. Trench systems located very close to surface water resource areas may not provide sufficient downgradient travel time for stabilization of groundwater chemistry before groundwater discharge to the surface water. Trenching options would generate a significant volume of soil that would need to be disposed of off-site and would likely also require an area for temporary stockpile staging.

An alternative approach for installation is to use soil borings for in-situ delivery of reactive materials. The most common amendments for this application are slow-release organic carbon electron donor substrates, such as food-grade emulsified soy bean oil. These soil boring PRB installations could be located upgradient away from resource areas and installed with minimal disturbance at the ground surface. The soil boring methods and emulsified soil bean oil have been commonly applied for in-situ treatment of nitrate and other groundwater contaminants at thousands of sites that have been closely monitored.

Denitrification PRB construction utilizing soil borings to place solid substrates such as elemental sulfur or for the placement of electrodes to generate amendments in the subsurface with electrochemical methods are more experimental but show promise.

PRB demonstration objectives generally include proof of performance and identifying design and operational factors that will influence cost and successful implementation and operation at full scale.

Specific objectives for a PRB demonstration include:

(1) Conducting testing representative of full scale application;

(2) Providing proof of nitrogen concentration and load reduction to extrapolate to (TMDL) reduction targets at full scale;

(3) Obtaining data for engineering evaluations and full scale cost estimates;

(4) Confirming time frame for technology performance; and

(5) Demonstrating programs for performance, compliance monitoring, and assessment of treated water quality.

3. Demonstration Site Identification Process

Potential PRB locations identified on the Consensus Plan Hybrid Map and additional locations were further 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 the following steps:

- Review of potential PRB locations developed through the Consensus Planning process;

- Review of Nauset, Pleasant Bay and Cape Cod Bay watersheds to identify potential demonstration locations that may not have been previously identified or variations on the identified locations;
- Assessment of potential PRB nitrogen reductions with the online WatershedMVP Multi-variant Planning tool developed by the Cape Cod Commission (http://www.watershedmvp.org/);
- Initial field visits to potential sites;
- Review of existing soil and/or groundwater quality data, where available;
- Discussion of potential demonstration sites with Town of Orleans officials;
- Refinement of criteria to be used in the Site Selection Matrix;
- Submission of the Site Selection Matrix to Town of Orleans for review;
- Ranking of sites based on criteria using Site Selection Matrix;
- Reviewing preferred PRB demonstration sites that resulted from the Site Selection Matrix process; and
- Recommending site locations for additional field investigation and Work Plan cost estimates.

This Technical Memorandum reports on the findings of these tasks.

It is important to note that while efforts were made to evaluate all available information regarding the geology and hydrogeology of potential PRB demonstration locations, site specific information is very limited. The local direction of groundwater flow has been assumed based on regional groundwater contours from the 1995 Cape Cod Commission Orleans Water Table Mapping Project (Cape Cod Commission, 1995). Water table elevations may vary locally resulting in deviations in local groundwater flow direction that affect the hydraulic capture zone of a PRB and the transport of treated groundwater downgradient.

Collection of limited site specific information, through investigations including the installation of groundwater monitoring wells and groundwater sampling was completed by AECOM in 2016 on selected sites. The investigations will be used to assess groundwater flow directions, groundwater chemistry, and the vertical distribution of nitrogen compounds in groundwater at key locations. Information and observations generated in these assessments will be reviewed and incorporated into this Technical Memorandum and the Preliminary Engineering Work Plan for Permeable Reactive Barriers.

4. Selected PRB Sites for Characterization and Evaluation

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

A - Main Street and Tonset Road (Main Street);

B - South Orleans Road at Tonset/Eldredge Parkway (Route 28 site);

C - Town Cove Gibson Road;

D - Namequoit Road;

E - Town Landfill;

F - Paw Wah Pond;

G - Rock Harbor Road Area; and

H - Kescayo Gansett Pond (Lonnie's Pond).

The eight locations are shown on Figure 2.

Information regarding selected potential PRB demonstration sites is provided in Section 4a. for use in assessing the locations against Site Suitability Criteria presented in Section 5. Based on the eight (8) locations identified above, thirteen (13) preliminary full scale PRB scenarios were evaluated for nitrogen reduction with WatershedMVP to assess the benefit and efficiency of various theoretical PRBs at full length. In some cases both shallow and deep groundwater treatment scenarios were considered. The WatershedMVP tool, developed by the Cape Cod Commission, evaluates nitrogen load based on land use in the watershed and was used to predict nitrogen load reductions based on hydraulic capture zone of a theoretical PRB at each site. A summary of WatershedMVP nitrogen load estimates for each scenario is included in Table 1 and Figures 3 and 4.

1) Description of Potential Sites in the Nauset watershed

The Massachusetts Estuaries Project (MEP) target nitrogen load reduction for the Nauset Harbor system is approximately 8,600 kg N/year, while the Town Cove sub-embayment target load reduction is approximately 6,700 kg N/year (Howes, et.al. 2012). PRBs may be implemented to remove a portion of these nitrogen load reduction targets.

Four potential locations were identified in the Nauset watershed with projected groundwater discharge to Town Cove including the Main Street site, the Route 28 site, the Town Landfill, and the Gibson Road site.

(1) Main Street and Tonset Road (Main Street Site)

The Main Street site is located close to Town Cove (~350 feet), and the full-scale PRB was projected to extend 2,250 feet along Main Street and Tonset Road in an area of mixed residential and commercial development. The depth to groundwater along Main Street is approximately 14 ft below ground surface (bgs), and the depth to groundwater along Tonset Road is approximately 32 ft bgs. WatershedMVP was used to estimate intercepted nitrogen load based on land use in the upgradient area. The WatershedMVP assessment calculated that the PRB would capture the nitrogen load from all upgradient areas of the watershed totaling an estimated 965 kilograms per year (kg/yr). Based on the WatershedMVP calculated output, assuming an effective nitrogen load reduction of 75%, a full-scale PRB would remove approximately 720 kg/yr or an estimated 0.32 kg/yr/ft of PRB length. This estimate did not include nitrogen in groundwater originating at the upgradient Orleans Town landfill that may add substantially to the projected nitrogen load intercepted.

(2) South Orleans Road at Tonset/Eldredge Parkway (Route 28 Site)

The Route 28 site is located approximately 1,200 feet upgradient of Main Street along Route 28 (South Orleans Road) near the intersection of South Orleans Road, Tonset Road, and Eldredge Parkway. This site is considered a variation of the Main Street site, and the results of demonstration at Route 28 could also be applied to full scale implementation at the Main Street Site. The land between these two potential PRBs includes a wooded swamp area that

may have local effects on the direction of groundwater flow that may affect the layout of a PRB demonstration on Main Street.

Site specific groundwater data is available from previous investigations. Several groundwater monitoring wells installed for a separate investigation at the Police Station have been identified. The depth to groundwater at Route 28 is approximately 30 ft. The full-scale PRB is projected to extend 900 feet along Route 28 and in an area of mixed residential and commercial development with Town facilities including the Orleans Police Station and adjacent Eldredge Park. This PRB would capture the nitrogen load from all upgradient areas of the watershed calculated with WatershedMVP to total an estimated 710 kg/yr. Based on the WatershedMVP calculation and assuming a nitrogen load reduction of 75%, the PRB would remove approximately 530 kg/yr or 0.59 kg/yr/ft of PRB. This location could potentially remove the most nitrate from the groundwater, and therefore be the most cost effective, on a per foot basis. This location is also potentially in the groundwater flow path of nitrogen originating at the upgradient Orleans Town landfill. However, this estimate does not include nitrogen sources from the landfill that may add substantially to the projected nitrate load reduction.

(3) Town Cove Gibson Road

The Gibson Road site is located on the east side of Town Cove on Gibson Road. The full-scale PRB was projected to extend 2,500 feet along Gibson Road in an area of residential development. Based on regional maps the depth to groundwater is approximately 23 ft but variable with rolling topography. The WatershedMVP model estimates that the PRB would capture the nitrogen load from all upgradient areas of the watershed totaling approximately 810 kg/yr. Based on the WatershedMVP output, assuming a nitrogen load reduction of 75%, the PRB would remove 610 kg/yr or 0.24 kg/yr/ft of PRB.

(4) Orleans Town Landfill Site

The Orleans Town Landfill site consists of approximately 20 acres located off Lots Hollow Road near the top of the Nauset watershed. Site specific groundwater data is available from previous investigations. The depth to groundwater is approximately 45 ft bgs at the lowest point of land elevation at the landfill but increases significantly downgradient as the land surface is higher. A previous review of groundwater monitoring data from monitoring wells routinely sampled at the landfill indicated significant concentrations of nitrate in groundwater downgradient of the landfill and former septage lagoons (MT Environmental Restoration, April, 2015). The nitrogen load from the landfill cannot be predicted with WatershedMVP because it uses parcel based land use and water supply data to estimate nitrogen loads in the groundwater. rather than actual groundwater data that would be required for this type of location. While insufficient data is available to estimate nitrate mass transport in groundwater from the landfill, it is likely significant. Recent groundwater data from the routine landfill monitoring well sampling program (October 2015) included the first data quantifying total nitrogen in addition to nitrate in samples from landfill monitoring wells. These data indicated significant nitrate concentrations in the shallow groundwater and relatively low nitrogen concentrations deeper in the aquifer. These data indicate a potential plume of ammonia (not directly analyzed) in the deeper groundwater that cannot be treated by denitrification without including an additional aerobic step converting the ammonia to nitrate.

2) Description of Potential Sites in the Pleasant Bay Watershed

The target nitrogen load reduction for the Pleasant Bay System is approximately 17,000 kg N/year (Howes, et.al. 2006). The Pleasant Bay system has numerous inlets and connected salt ponds, each with its own sub-watershed. Pleasant Bay has been designated An Area of Critical Environmental Concern (ACEC) under MGL ch. 21A Section 2 (7). The effect of designation as an ACEC compels the State to ensure that activities within or impacting the ACEC are carried out so as to minimize adverse effects. Locating a PRB within an ACEC would be anticipated to result in additional permitting costs and/or potentially reduce public acceptance. The Pleasant Bay ACEC extends inland to the 10-foot contour plus 100 feet.

Three potential locations were assessed in the Pleasant Bay watershed.

(1) Namequoit Road

The Namequoit Road site is located along Namequoit Road upgradient of the Namequoit River, the inlet to Areys Pond off Pleasant Bay. This location would be within the Pleasant Bay ACEC. The full-scale PRB was projected to extend 1,100 feet in an area of residential development. The depth to groundwater ranges approximately 25 to 55 ft along the proposed PRB length due to uneven topography. The PRB would capture the nitrogen load from all developed upgradient areas of the watershed with a WatershedMVP estimate of 180 kg/yr. Based on the WatershedMVP output, assuming a nitrogen load reduction of 75%, the PRB would remove approximately 130 kg/yr or 0.12 kg/yr/ft of PRB length.

(2) Paw W, ah Pond

The Paw Wah Pond site is located along Lockwood Lane, a private unpaved road upgradient of Paw Wah Pond and within the Pleasant Bay ACEC. The full-scale PRB was projected to extend 800 feet in an area of residential development. The depth to groundwater is approximately 21 ft bgs. The PRB would capture the nitrogen load from all upgradient areas of the watershed with the WatershedMVP estimate totaling approximately 110 kg/yr. Based on the WatershedMVP output, assuming a nitrogen load reduction of 75%, the PRB would remove approximately 80 kg/yr or 0.10 kg/yr/ft of PRB length.

(3) Kescayo Gansett Pond/Lonnie's Pond

The Lonnie's Pond site is located along Herring Brook Road within the Pleasant Bay ACEC. The full-scale PRB was projected to extend 1,000 feet in an area of residential development. The depth to groundwater ranges from approximately 2 to 22 ft bgs, with deepest depth to groundwater at the northern end. The PRB was projected to capture the nitrogen load from the watershed with the WatershedMVP estimate totaling 120 kg/yr. Based on the WatershedMVP output, assuming a nitrogen load reduction of 75%, the PRB would remove approximately 90 kg/yr or 0.09 kg/yr/ft of PRB length.

3) Description of Potential Sites in the Cape Cod Bay Watershed

One potential location was assessed in the Cape Cod Bay watershed. Inner Cape Cod Bay is also an ACEC with the landward extent to the 10-foot contour.

(1) Rock Harbor Road Area Site

The Rock Harbor Road Area Site location evaluated is along Captains Row, an unpaved road off Rock Harbor Road extending approximately 700 ft east to west upgradient of Rock Harbor. The location is outside the Cape Cod Bay ACEC in an area of residential development. The depth to groundwater ranges from approximately 10 to 20 ft bgs. The PRB was projected to capture approximately 180 kg/yr with WatershedMVP. Based on the WatershedMVP output, assuming a nitrogen load reduction of 75%, the PRB would remove approximately 130 kg/yr or 0.19 kg/yr/ft of PRB length.

Figures 1 and 2 provide a comparison of the estimated nitrate loads removed at each of the evaluated locations.

5. Site Suitability Criteria and Analysis

1) Site Selection Matrix

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 Site Selection Matrix includes the following criteria:

Site Suitability:

- Downgradient Water Use – Public water supply wells (PRBs locations should not be located where potable water supply wells are located nearby and downgradient)
- Topography - Significant changes in elevation may affect construction and monitoring
- Depth to Groundwater - Deeper water table increases costs and may affect feasibility
- Groundwater Nitrogen Profile - Nitrate concentrations and concentrations change with depth in groundwater -addresses feasibility
- Groundwater Flow Direction and Velocity - Necessary for orientation of PRB and assessing nitrate flux and cost effectiveness
- Ease of Access/Use of Property
- Representativeness - Transferability of lessons learned from demonstration testing/meets target conditions for a PRB

Permitting:

- Outside ACEC, Upland Areas (reduced permitting requirements for PRB placement)
- Abutter Compatibility
- Property Ownership/Road Layout (ease of access for PRB placement)
- Utility Conflicts (feasibility for PRB placement)

Project Evaluation:

- Nitrogen Removal Efficiency (utility and cost effectiveness)
- Overall Ease of Monitoring (cost benefit and enhancement of performance data collection to meet demonstration goals)
- Accessible Well Locations
- Quantity/Quality of Existing Information (cost benefit)

Other/Overriding Considerations:

- Community Acceptability
- Potential for Public Education
- Potential for Watershed/Estuary Impacts (distance from surface water and wetland resource areas/ water use considerations)
- Funding Potential
- Potential for Full Scale Implementation

2) Analysis

The PRB Technical Team collected site specific information, conducted site visits, and evaluated the potential performance effectiveness of selected PRB locations with the WatershedMVP utility. 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.

For the Site Suitability criteria, if a site was fully suitable based on the criterion being ranked, it was assigned a numerical value of 1. If the site was mostly suitable based on the criterion being ranked. It was assigned a ranking of 0 and if the site was mostly unsuitable, it was assigned a ranking of -1.

For the Permitting criteria, if a site was likely to be permitted and attain all regulatory approval based on the criterion being ranked, it was assigned a numerical value of 1. If the site was likely to be permitted, but there were potential issues related to the criteria, it was assigned a ranking of 0. If the site was more difficult to permit and receive all regulatory approval, it was assigned a ranking of -1.

For the Project Evaluation criteria, if a site was likely to produce a representative PRB demonstration based on the criterion being ranked, it was assigned a numerical value of 1. If the site was probably able to produce a representative demonstration it was assigned a ranking of 0. If a demonstration was unlikely to be representative at a site it was assigned a ranking of -1.

Quantitative rankings were tabulated in the Site Selection Matrix (Table 2). Results of the PRB site evaluation are discussed in Section 6.

6. Findings and Recommendations

The site suitability evaluation process narrowed the list of potential Demonstration Test sites to the following four locations:

1) Main Street and Tonset Road (Site A);

2) South Orleans Road at Tonset/Eldredge Parkway (Site B);

3) Town Cove Gibson Road (Site C); and

4) Town Landfill (Site E).

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 within Orleans. One additional demonstration site was identified at the Town Landfill (Site E). A demonstration test he landfill site could also be implemented given sufficient funding.

7. References

Cape Cod Commission 1995, Orleans Water Table Mapping Project

Howes B., S. W. Kelley, J. S. Ramsey, R. Samimy, D. Schlezinger, E. Eichner (2012). Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Nauset Harbor Embayment System Towns of Orleans and Eastham, Massachusetts

Howes B., S. W. Kelley, J. S. Ramsey, R. Samimy, D. Schlezinger, E. Eichner (2006).

Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Pleasant Bay, Chatham, Massachusetts. Massachusetts Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA.

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

Walter, D.A., Masterson, J.P., and Hess, K.M., 2004, Ground-water recharge areas and travel times to pumped wells, ponds, streams, and coastal water bodies, Cape Cod, Massachusetts: U.S. Geological Survey Scientific Investigations Map I-2857, 1 sheet [http://pubs.usgs.gov/sim/2004/2857/].

Wright-Pierce, December 2010, Town of Orleans Comprehensive Wastewater Management Plan and Single Environmental Impact Report.

270 Parcels
96,500 GPD

286 Parcels
45,600 GPD

178 Beach Road

223 Beach Road

Tri-Town Site

9 West Road

Potential Reclaimed Water Line

Clover Leaf Route 6A

29 Baker's Pond Road

Potential Disposal/Treatment Site in Brewster Site A

Potential Disposal/Treatment Site in Brewster Site B

Rock Harbor
Little Namskaket
Namskaket
Cedar Pond
Town Cove
Mill Pond
Meetinghouse Pond
Uncle Harvey's Pond
Upper River
Crystal Lake
Lonies Pond
Pochet
Baker's Pond
Pilgrim Lake
Lower River
Namequoit River
Arey's Pond
Uncle Israel's Pond
Twinings Pond
Sarah's Pond
Shoal Pond
Meadow Bog Pond
Deep Pond
Quanset
PLEASANT BAY
HARWICH
CHATHAM

Legend

- Floating Constructed Wetlands
- Coastal Habitat Restoration
- PRB_hybrid
- Aquaculture Area
- Coastal Habitat Restoration Area
- Floating Constructed Wetlands Area
- Potential Reclaimed Water Line
- Potential Reclaimed Water Sites
- Landfill
- 4 Nauset Middle School
- B Tri-Town
- Downtown Sewered Area
- Meetinghouse Sewered Area

Potential Disposal/Treatment Sites

- Site 5 - Tri-Town Disposal
- Site 6 - Tri-Town Disposal
- Site 7 - Tri-Town Disposal
- Site 15 - Meeting house/Pochet Treatment/Disposal
- Site 16 - Meeting house/Pochet Treatment/Disposal
- Site 21 - S. Orleans Treatment/Disposal
- Watershed Boundary
- Subwatershed Boundary

General Notes
1. 25% Nitrogen reduction from fertilizer management is applied to all watersheds.
2. All non-sewered area septage to be hauled and treated at the Tri-Town facility.
3. Sludge from decentralized treatment systems to be hauled and treated at the Tri-Town facility.
4. Wastewater flows based on current parcel water usage.
5. Map locations shown for Non-Traditional technologies illustrate scale.Specific siting will occur during project planning and design.

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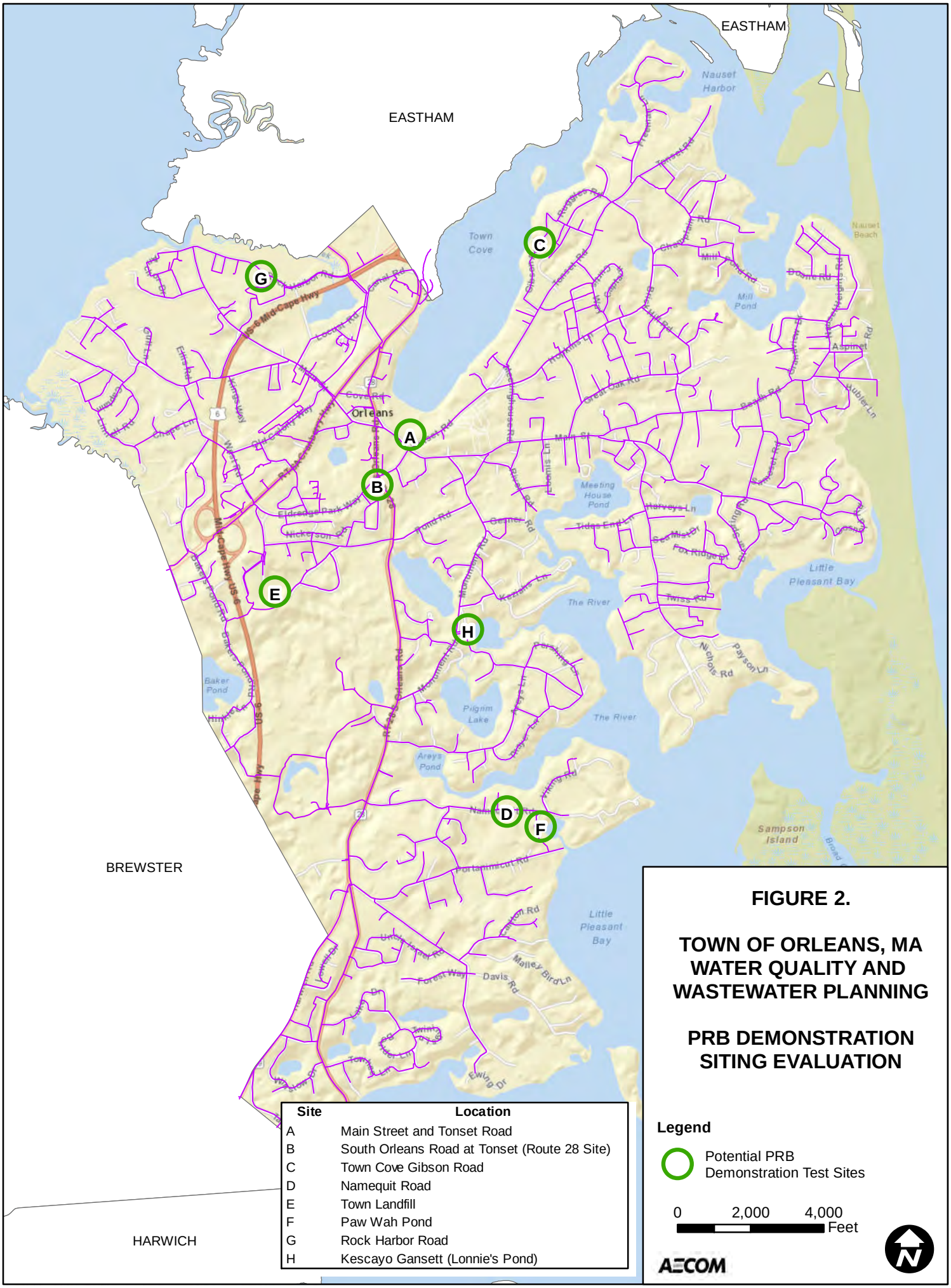
ORLEANS HYBRID VERSION 3
WQAP MEETING 2-11-15

TOWN OF ORLEANS
MASSACHUSETTS

FEBRUARY, 2015

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Site	Location
A	Main Street and Tonset Road
B	South Orleans Road at Tonset (Route 28 Site)
C	Town Cove Gibson Road
D	Namequit Road
E	Town Landfill
F	Paw Wah Pond
G	Rock Harbor Road
H	Kescayo Gansett (Lonnie's Pond)

FIGURE 2.

TOWN OF ORLEANS, MA WATER QUALITY AND WASTEWATER PLANNING

PRB DEMONSTRATION SITING EVALUATION

Legend

Potential PRB Demonstration Test Sites

0 2,000 4,000 Feet

AECOM

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Figure 3. MVP Calculated Nitrogen Load Removed - Full Scale PRB

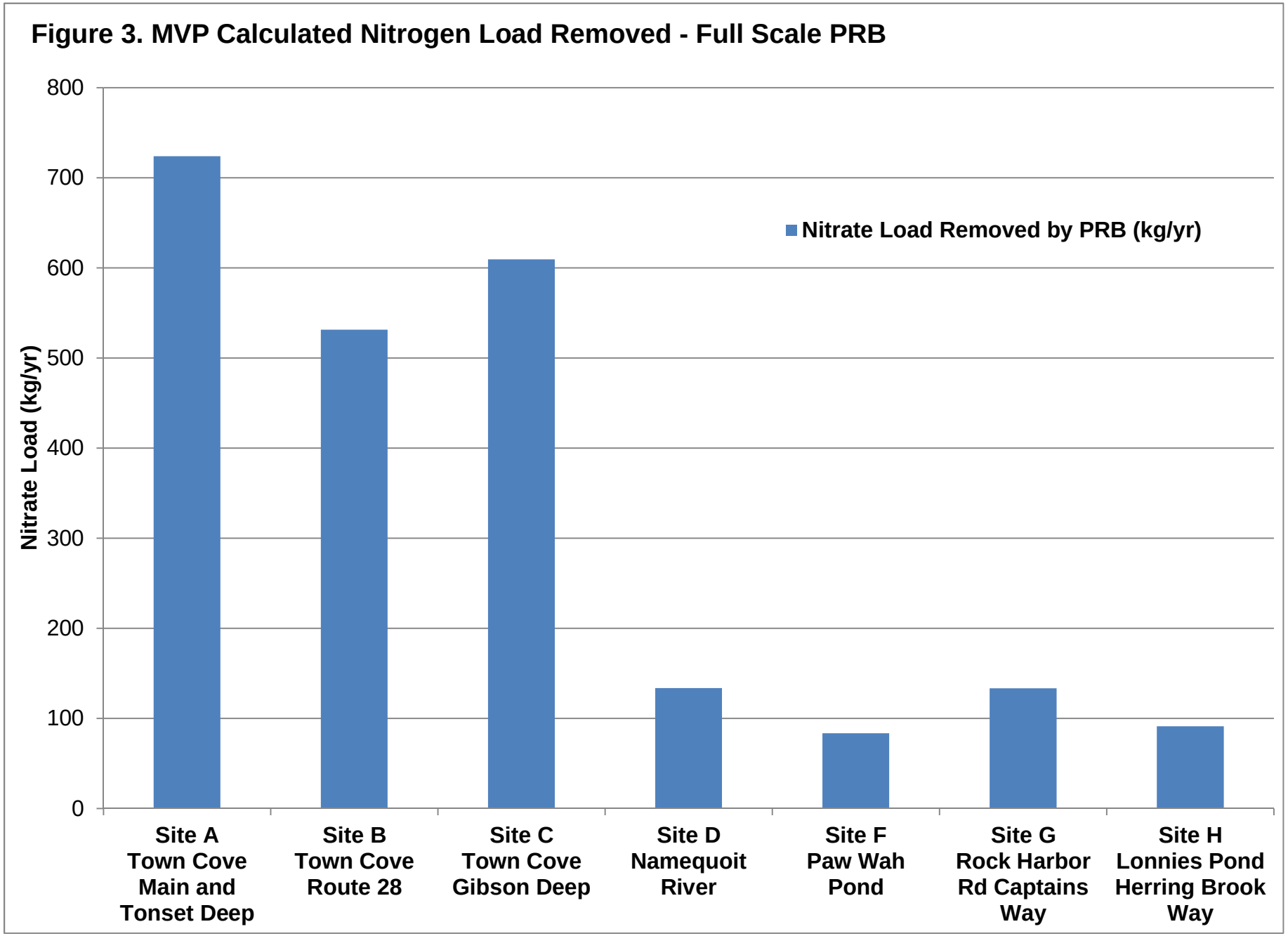


Figure 4. MVP Calculated Nitrate Load Removed Per PRB Length Unit

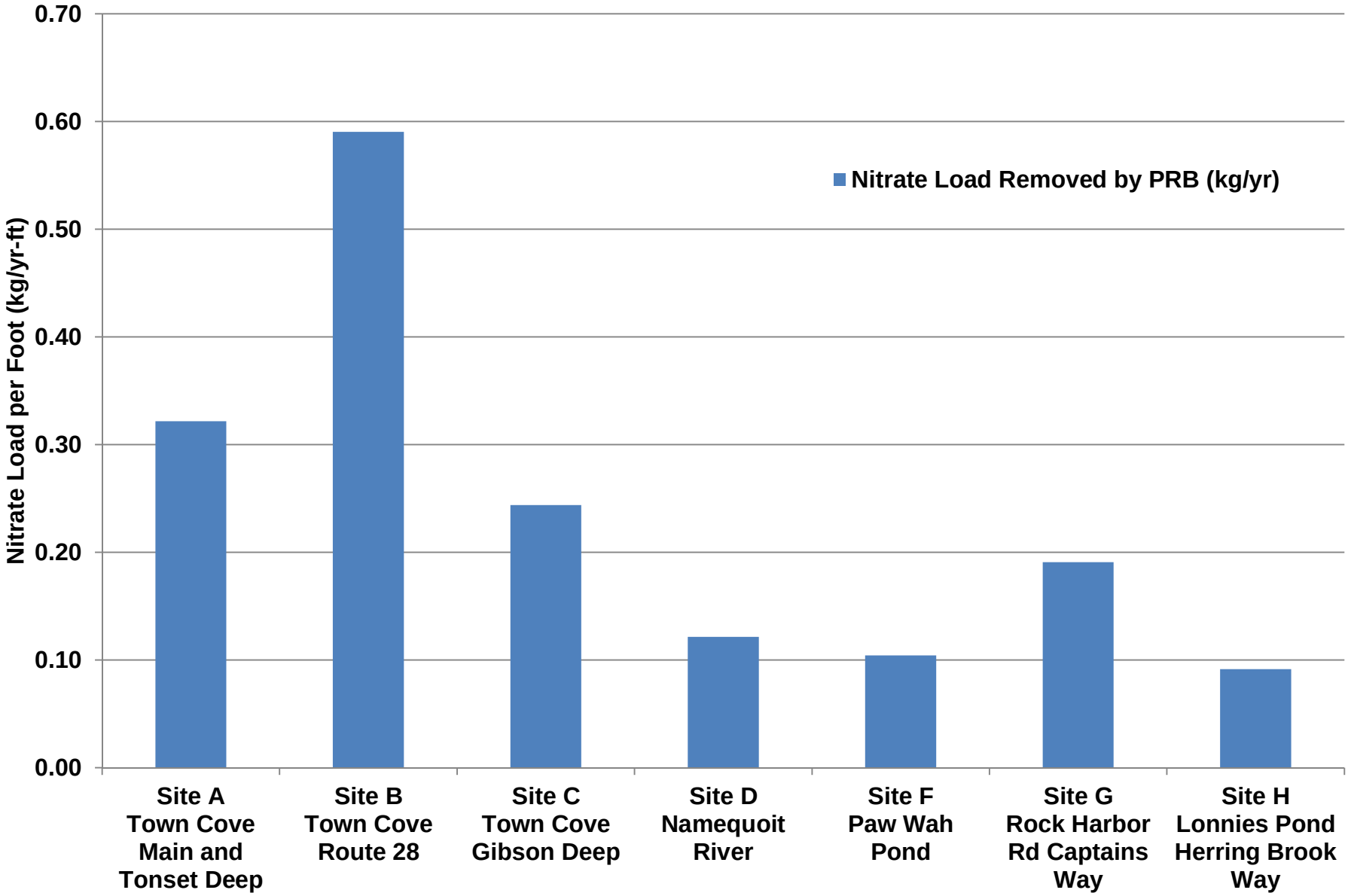


Table 1 WatershedMVP PRB Scenario Summary													
Scenario Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Description	Site A Town Cove Main and Tonset Deep	Town Cove Tonset Only	Town Cove Main St Only	Town Cove Main and Tonset Shallow	Site B Town Cove Route 28	Town Cove Gibson and Ruggles	Town Cove Ruggles Shallow	Site C Town Cove Gibson Deep	Town Cove Gibson And Ruggles Shallow	Site H Lonnies Pond Herring Brook Way	Site D Namequoit River	Site F Paw Wah Pond	Site G Rock Harbor Rd Captains Way
Total Properties In PRB Capture Area	192	95	97	96	104	272	55	217	137	36	38	23	38
Total Unsewered Properties In PRB Capture Area	192	95	97	96	104	272	55	217	137	36	38	23	38
MVP Estimated Nitrate Load (Sewer, Fert, Storm) In kg/yr	965	565	400	487	708	1,014	201	813	560	122	178	111	178
Nitrate Load From Other Sources (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Nitrate Load (kg/yr)	965	565	400	487	708	1,014	201	813	560	122	178	111	178
Percent Nitrate Reduction From PRB	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Nitrate Load Removed by PRB (kg/yr)	724	424	300	365	531	760	151	609	420	91	134	83	134
PRB Length (Feet)	2,250	1,300	950	2,250	900	3,725	1,225	2,500	3,725	1,000	1,100	800	700
Nitrate Load Removed Per Foot of PRB (kg/yr/ft)	0.322	0.326	0.316	0.162	0.590	0.204	0.123	0.244	0.113	0.091	0.122	0.104	0.191
Relative Estimated PRB Depth into Aquifer	Deep	Deep	Deep	Shallow	Shallow	Deep	Shallow	Deep	Shallow	Deep	Deep	Shallow	Deep

Town of Orleans, Massachusetts
Water Quality and Wastewater Planning
Table 2 - Permeable Reactive Barrier (PRB) Demonstration Siting Evaluation

Criteria	Criteria Weight	Site A Main Street and Tonset Road		Site B South Orleans Road at Tonset (RT-28 Site)		Site C Town Cove Gibson Road		Site D Namequoit Road		Site E Town Landfill		Site F Paw Wah Pond		Site G Rock Harbor Road		Site H Kescayo Gansett (Lonnie's Pond)	
		Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Site Suitability																	
Downgradient Potable Water Use - Wells	1	1	1	1	1	1	1	0	0	1	1	0	0	1	1	1	1
Topography	1	1	1	1	1	0	0	-1	-1	0	0	-1	-1	1	1	1	1
Depth to Groundwater	1	1	1	-1	-1	0	0	-1	-1	-1	-1	1	1	1	1	1	1
Groundwater Nitrogen Profile (concentration/depth)	1	1	1	1	1	-1	-1	-1	-1	1	1	-1	-1	-1	-1	-1	-1
Groundwater Flow Direction and Velocity	1	0	0	1	1	0	0	0	0	1	1	0	0	-1	-1	1	1
Ease of Access/Use of Property	1	1	1	1	1	-1	-1	1	1	1	1	-1	-1	1	1	0	0
Representativeness	1	1	1	1	1	1	1	-1	-1	0	0	-1	-1	0	0	-1	-1
Permitting																	
Outside ACEC, Upland Areas	1	1	1	1	1	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1
Abutter Compatibility	1	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0
Property Ownership/Road Layout	1	0	0	1	1	1	1	1	1	1	1	-1	-1	0	0	-1	-1
Utility Conflicts	1	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Project Evaluation																	
PRB Nitrogen Removal Efficiency	1	1	1	1	1	0	0	0	0	1	1	0	0	0	0	0	0
Overall Ease of Monitoring	1	0	0	1	1	0	0	0	0	0	0	-1	-1	0	0	-1	-1
Accessible Well Locations	1	0	0	1	1	1	1	1	1	0	0	-1	-1	0	0	0	0
Quantity/Quality of Existing Information	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Other/Overriding Considerations																	
Community Acceptability	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Potential for Public Education	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Potential for Watershed/Estuary Impacts	1	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0
Funding Potential	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potential for Full Scale Implementation	1	1	1	1	1	1	1	0	0	0	0	-1	-1	-1	-1	0	0
Total Criteria Points			**10**		**15**		**6**		**0**		**11**		**(7)**		**3**		**0**
Rank			**3**		**1**		**4**		**-**		**2**		**-**		**5**		**-**

Notes:
High Criteria Weight = Greater Importance
Higher Rating = Better Conditions

Remarks

Appendix B

Soil Boring Logs and Monitoring Well Coordinates

AECOM

GEOLOGIC LOG

PROJECT : Town of Orelans, MA Preliminary Investigation		SHEET	BORING NO.
SITE LOCATION:Orleans, MA	JOB NO.:	1 of 2	MW-A1-A
Groundwater Discharge Beds	LOCATION: 82 Main St, Orleans, MA 02653 N: E:	Elevation:	Total Depth: 40 ft
DRILL CONTRACTOR : NE Geotech	ENG/GEO : John Shannon	BEGUN : 1/20/16 8:15 AM	
DRILL RIG :	DRILLER : NE Geotech - Hayes	FINISHED : 1/20/16 12:30 PM	
Hole Size : 2 inch	Weather : Sunny. High 31, low 23 degrees. Winds WNW at 15 to 25	Ground Water (Date/Depth): Jan 20, 2016 / 8 ft.	
Drilling Method :	Drilling Fluid :	Top of Rock (Depth/Elev.) : N/A	

Depth (ft)	Sample Type/No.	N Value	Blow Count (per 6 in.) or Drilling Rate(min/ft)	Sample Recovery or REC & RQD	SAMPLE DESCRIPTION	ASTM CLASS	GENERALIZED STRATIGRAPHIC DESCRIPTION *(dashed where inferred)*
					0-5 ft - Vacum truck soft drilling of first 5 feet. Spoils used as backfill		2" well screen from 40' to 30'
5					5-8 ft. lt. brown to tan, coarse to fine SAND with trace v. coarse sand and gravel		
					8-9 ft. black, oily, coarse to fine SAND		
10					9-18.5 ft. tan to brown, coarse to fine SAND with trace silt		
15							
					18.5-19.5 ft. brown, very coarse SAND		

Sample Types:			SPT Resistance		Approve/Date
SS = Split Spoon	trace	0 to 5%			
ST = Shelby Tube	few	5 to 10%			
R = Rock Core	little	15 to 25%	Cohesionless Density: 0-4 Very Loose	Cohesive Consistenc 0-2 Very Soft	
= Lab Sample	some	30 to 45%	5-9 Loose 10-29 Med. Dense	3-4 Soft, 5-8 M/Stiff, 9-15 Stiff	
	mostly	>50%	30-49 Dense 50+ Very Dense	16-30 V-Stiff, 31+ Hard	

AECOM

GEOLOGIC LOG

PROJECT : Town of Orelans, MA Preliminary Investigation		SHEET 2 of 2	BORING NO.
SITE LOCATION:Orleans, MA	JOB NO.:		
Groundwater Discharge Beds	LOCATION: 82 Main St, Orleans, MA 02653 N: E:	Elevation:	Total Depth: 40 ft
DRILL CONTRACTOR : NE Geotech	ENG/GEO : John Shannon	BEGUN : 1/20/16 8:15 AM	
DRILL RIG :	DRILLER : NE Geotech - Hayes	FINISHED : 1/20/16 12:30 PM	
Hole Size : 2 inch	Weather : Sunny. High 31, low 23 degrees. Winds WNW at 15 to 25	Ground Water (Date/Depth): Jan 20, 2016 / 8 ft.	
Drilling Method :	Drilling Fluid :	Top of Rock (Depth/Elev.) : N/A	

Depth (ft)	Sample Type/No.	N Value	Blow Count (per 6 in.) or Drilling Rate(min/ft)	Sample Recovery or REC & RQD	SAMPLE DESCRIPTION	ASTM CLASS	GENERALIZED STRATIGRAPHIC DESCRIPTION *(dashed where inferred)*
					(continued)		
					19.5-23 ft. tan to brown, coarse to medium SAND		
					23-23.5 ft. Clay		
25					23.5-27.5 ft. reddish brown, very coarse to coarse SAND		Gravel seam 26.5 ft. Clay seam - 27 ft.
					27.5-29 ft. tan to lt. brown, fine SAND and SILT		
30					29-36 ft. dark tan to brown, medium to fine SAND with trace silt		
35					36-40 ft. tan to brown, medium to fine SAND with trace silt and clay		
					(bottom of boring)		

Sample Types:			SPT Resistance		Approve/Date
SS = Split Spoon	trace	0 to 5%			
ST = Shelby Tube	few	5 to 10%			
R = Rock Core	little	15 to 25%	Cohesionless Density: 0-4 Very Loose	Cohesive Consistenc 0-2 Very Soft	
= Lab Sample	some	30 to 45%	5-9 Loose 10-29 Med. Dense	3-4 Soft, 5-8 M/Stiff, 9-15 Stiff	
	mostly	>50%	30-49 Dense 50+ Very Dense	16-30 V-Stiff, 31+ Hard	

AECOM

GEOLOGIC LOG

PROJECT : Town of Orelans, MA Preliminary Investigation		SHEET	BORING NO.
SITE LOCATION:Orleans, MA	JOB NO.:	1 of 3	MW-A3-A
Groundwater Discharge Beds	LOCATION: 67 Main St, Orleans, MA 02653 N: E:	Elevation:	Total Depth: 60 ft
DRILL CONTRACTOR : NE Geotech	ENG/GEO : John Shannon	BEGUN : 1/19/16 10:00 AM	
DRILL RIG :	DRILLER : NE Geotech - Hayes	FINISHED : 1/19/16 3:00 PM	
Hole Size : 2 inch	Weather : Sunny and cold, 17 degrees. Very windy	Ground Water (Date/Depth) : Jan 19, 2016 / 24. (perched water table at 12.5 ft)	
Drilling Method :	Drilling Fluid :	Top of Rock (Depth/Elev.) : N/A	

Depth (ft)	Sample Type/No.	N Value	Blow Count (per 6 in.) or Drilling Rate(min/ft)	Sample Recovery or REC & RQD	SAMPLE DESCRIPTION	ASTM CLASS	GENERALIZED STRATIGRAPHIC DESCRIPTION *(dashed where inferred)*
					0-5 ft - Vacum truck soft drilling of first 5 feet. Spoils used as backfill		2" well screen from 56' to 46'
5					5-7 ft. light brown, fine SAND with trace silt		
					7-12 ft. tan to light brown, medium to fine SAND with trace silt		
10							Gravel lens at 12 ft.
					12-13 ft. fine SAND with trace silt		Clay lens at 13 ft.
					13-15 ft. tan to light brown coarse to very coarse SAND with trace gravel and silt		Perched water - 12.5 ft
15					15-17 ft. reddish brown to dark tan layered clay and coarse SAND		
					17-19 ft. dull gray CLAY with trace silt		
					19-20 ft. reddish brown to light tan, medium SAND with trace silt		

Sample Types:		SPT Resistance		Approve/Date
SS = Split Spoon	trace 0 to 5%			
ST = Shelby Tube	few 5 to 10%			
R = Rock Core	little 15 to 25%	Cohesionless Density: 0-4 Very Loose	Cohesive Consistenc 0-2 Very Soft	
= Lab Sample	some 30 to 45%	5-9 Loose 10-29 Med. Dense	3-4 Soft, 5-8 M/Stiff, 9-15 Stiff	
	mostly >50%	30-49 Dense 50+ Very Dense	16-30 V-Stiff, 31+ Hard	

AECOM

GEOLOGIC LOG

PROJECT : Town of Orelans, MA Preliminary Investigation		SHEET 2 of 3	BORING NO.
SITE LOCATION:Orleans, MA	JOB NO.:		
Groundwater Discharge Beds	LOCATION: 67 Main St, Orleans, MA 02653 N: E:	Elevation:	Total Depth:60ft
DRILL CONTRACTOR : NE Geotech	ENG/GEO : John Shannon	BEGUN : 1/19/16 10:00 AM	
DRILL RIG :	DRILLER : NE Geotech - Hayes	FINISHED : 1/19/16 3:00 PM	
Hole Size : 2 inch	Weather : Sunny and cold, 17 degrees. Very windy	Ground Water (Date/Depth) : 24.5 ft / Jan 19, 20 (perched water table at 12.5 ft)	
Drilling Method :	Drilling Fluid :	Top of Rock (Depth/Elev.) : N/A	

Depth (ft)	Sample Type/No.	N Value	Blow Count (per 6 in.) or Drilling Rate(min/ft)	Sample Recovery or REC & RQD	SAMPLE DESCRIPTION	ASTM CLASS	GENERALIZED STRATIGRAPHIC DESCRIPTION *(dashed where inferred)*
					20-22 ft. brown to light tan, coarse to medium SAND with trace silt		Clay seam - 22 ft.
					22-24 ft. light tan medium to fine SAND with trace silt		
25					24-25 ft. tan to gray, SILT and CLAY with trace fine sand		
					25-27 ft. light tan, coarse to medium SAND		
					27-29.5 ft. light tan, fine SAND with some silt and gray clay		
30					29.5-40 ft. to to lt. brown, coarse to medium SAND with trace silt		
35							

Sample Types:			SPT Resistance		Approve/Date
SS = Split Spoon	trace	0 to 5%			
ST = Shelby Tube	few	5 to 10%			
R = Rock Core	little	15 to 25%	Cohesionless Density: 0-4 Very Loose	Cohesive Consistenc 0-2 Very Soft	
= Lab Sample	some	30 to 45%	5-9 Loose 10-29 Med. Dense	3-4 Soft, 5-8 M/Stiff, 9-15 Stiff	
	mostly	>50%	30-49 Dense 50+ Very Dense	16-30 V-Stiff, 31+ Hard	

GEOLOGIC LOG

AECOM

PROJECT : Town of Orelans, MA Preliminary Investigation		SHEET 3 of 3	BORING NO.
SITE LOCATION:Orleans, MA	JOB NO.:		
Groundwater Discharge Beds	LOCATION: 67 Main St, Orleans, MA 02653 N: E:	Elevation:	Total Depth:60ft
DRILL CONTRACTOR : NE Geotech	ENG/GEO : John Shannon	BEGUN : 1/19/16 10:00 AM	
DRILL RIG :	DRILLER : NE Geotech - Hayes	FINISHED : 1/19/16 3:00 PM	
Hole Size : 2 inch	Weather : Sunny and cold, 17 degrees. Very windy	Ground Water (Date/Depth) : 24.5 ft / Jan 19, 20 (perched water table at 12.5 ft)	
Drilling Method :	Drilling Fluid :	Top of Rock (Depth/Elev.) : N/A	

Depth (ft)	Sample Type/No.	N Value	Blow Count (per 6 in.) or Drilling Rate(min/ft)	Sample Recovery or REC & RQD	SAMPLE DESCRIPTION	ASTM CLASS	GENERALIZED STRATIGRAPHIC DESCRIPTION *(dashed where inferred)*
					40-42 ft. dark tan coarse to very coarse SAND with trace silt		
					42-43 ft. brown to light tan medium to fine SAND with trace silt		
45					43-47 ft. dark tan, coarse to medium SAND with trace silt		
					47-48 ft. light brown medium to fine SAND		
50					48-53.5 tan to light brown coarse to medium SAND with trace silt		
55					53.5-55 ft. tan to light brown fine SAND with trace silt		
					55-57 ft. dark tan, medium to fine SAND		
					57-58 ft. gray CLAY with trace silt and fine sand		
60					58-60 ft. tan to light brown, medium to fine SAND (botton of boring)		

Sample Types:			SPT Resistance		Approve/Date
SS = Split Spoon	trace	0 to 5%			
ST = Shelby Tube	few	5 to 10%			
R = Rock Core	little	15 to 25%	Cohesionless Density: 0-4 Very Loose	Cohesive Consistenc 0-2 Very Soft	
= Lab Sample	some	30 to 45%	5-9 Loose 10-29 Med. Dense	3-4 Soft, 5-8 M/Stiff, 9-15 Stiff	
	mostly	>50%	30-49 Dense 50+ Very Dense	16-30 V-Stiff, 31+ Hard	

AECOM

GEOLOGIC LOG

PROJECT : Town of Orelans, MA Preliminary Investigation		SHEET 1 of 4	BORING NO. MW-E6-A
SITE LOCATION: Orleans, MA	JOB NO.:		
Groundwater Discharge Beds	LOCATION: Town of Orleans Landfill N: E:	Elevation:	Total Depth: 75 ft
DRILL CONTRACTOR : NE Geotech	ENG/GEO : John Shannon	BEGUN : 1/21/16 7:30 AM	
DRILL RIG :	DRILLER : NE Geotech - Hayes	FINISHED : 1/21/16 2:00 PM	
Hole Size: 2 inch	Weather : Overcast and cold, High 40, low 32.	Ground Water (Date/Depth): Jan 21, 2016 / 55 f	
Drilling Method :	Drilling Fluid :	Top of Rock (Depth/Elev.) :	

Depth (ft)	Sample Type/No.	N Value	Blow Count (per 6 in.) or Drilling Rate(min/ft)	Sample Recovery or REC & RQD	SAMPLE DESCRIPTION	ASTM CLASS	GENERALIZED STRATIGRAPHIC DESCRIPTION *(dashed where inferred)*
					0-5 ft - Vacum truck soft drilling of first 5 feet. Spoils used as backfill		2" well screen from 75' to 65'
5					5-9 ft. light to dark brown, coarse to medium SAND with trace silt		
10					9-13 ft. tan to brown, very coarse to medium SAND with trace silt		
15					13-17 ft. tan to light brown, very coarse SAND		Gravel lens - 17 ft.
					17-18 ft. tan to light brown, coarse to medium SAND		
					18-25.5 ft. tan to lt. brown, v. coarse SAND with some gravel		
					(continued)		

Sample Types:	trace 0 to 5%	SPT Resistance		Approve/Date
SS = Split Spoon	few 5 to 10%			
ST = Shelby Tube	little 15 to 25%	Cohesionless Density: 0-4 Very Loose	Cohesive Consistenc 0-2 Very Soft	
R = Rock Core	some 30 to 45%	5-9 Loose 10-29 Med. Dense	3-4 Soft, 5-8 M/Stiff, 9-15 Stiff	
= Lab Sample	mostly >50%	30-49 Dense 50+ Very Dense	16-30 V-Stiff, 31+ Hard	

AECOM

GEOLOGIC LOG

PROJECT : Town of Orelans, MA Preliminary Investigation		SHEET	BORING NO.
SITE LOCATION: Orleans, MA	JOB NO.:	2 of 4	MW-E6-A
Groundwater Discharge Beds	LOCATION: Town of Orleans Landfill N: E:	Elevation:	Total Depth: 60 ft
DRILL CONTRACTOR : NE Geotech	ENG/GEO : John Shannon	BEGUN : 1/21/16 7:30 AM	
DRILL RIG :	DRILLER : NE Geotech - Hayes	FINISHED : 1/21/16 2:00 PM	
Hole Size: 2 inch	Weather : Overcast and cold, High 40, low 32.	Ground Water (Date/Depth): Jan 21, 2016 / 55 f	
Drilling Method :	Drilling Fluid :	Top of Rock (Depth/Elev.) :	

Depth (ft)	Sample Type/No.	N Value	Blow Count (per 6 in.) or Drilling Rate(min/ft)	Sample Recovery or REC & RQD	SAMPLE DESCRIPTION	ASTM CLASS	GENERALIZED STRATIGRAPHIC DESCRIPTION *(dashed where inferred)*
					18-25.5 ft. tan to lt. brown, v. coarse SAND with some gravel		
25					25.5-26 ft. tan to lt. brown, coarse to medium SAND		Silt seam - 25.5
					26-37.5 ft. tan to brown, very coarse SAND		Gravel lens - 29.5
30							medium Sand - 32.5
							Gravel lens - 34.5
35							Gravel lens - 35.5
					37.5-39 ft. tan, medium to fine SAND with trace silt		
					39-39.5 ft. light brown, coarse SAND		
					39.5-40.5 ft. tan, medium to fine SAND		

Sample Types:			SPT Resistance		Approve/Date
SS = Split Spoon	trace	0 to 5%			
ST = Shelby Tube	few	5 to 10%			
R = Rock Core	little	15 to 25%	Cohesionless Density: 0-4 Very Loose	Cohesive Consistenc 0-2 Very Soft	
= Lab Sample	some	30 to 45%	5-9 Loose 10-29 Med. Dense	3-4 Soft, 5-8 M/Stiff, 9-15 Stiff	
	mostly	>50%	30-49 Dense 50+ Very Dense	16-30 V-Stiff, 31+ Hard	

GEOLOGIC LOG

AECOM

PROJECT : Town of Orelans, MA Preliminary Investigation		SHEET	BORING NO.
SITE LOCATION: Orleans, MA	JOB NO.:	3 of 4	MW-E6-A
Groundwater Discharge Beds	LOCATION: Town of Orleans Landfill N: E:	Elevation:	Total Depth: 60 ft
DRILL CONTRACTOR : NE Geotech	ENG/GEO : John Shannon	BEGUN :	1/21/16 7:30 AM
DRILL RIG :	DRILLER : NE Geotech - Hayes	FINISHED :	1/21/16 2:00 PM
Hole Size: 2 inch	Weather : Overcast and cold, High 40, low 32.	Ground Water (Date/Depth): Jan 21, 2016 / 55 f	
Drilling Method :	Drilling Fluid :	Top of Rock (Depth/Elev.) :	

Depth (ft)	Sample Type/No.	N Value	Blow Count (per 6 in.) or Drilling Rate(min/ft)	Sample Recovery or REC & RQD	SAMPLE DESCRIPTION	ASTM CLASS	GENERALIZED STRATIGRAPHIC DESCRIPTION *(dashed where inferred)*
					(continued) 39.5-40.5 ft. tan, medium to fine SAND		
45					40.5-49 ft. tan to brown, very coarse SAND		Gravel lens - 43 Gravel lens 43.5
50					49-52 ft. tan to brown, coarse to medium SAND		
55					52-56 ft. tan to dark brown, medium to fine SAND with trace silt		
					56-60 ft. tan to dark brown, coarse SAND		

Sample Types:			SPT Resistance		Approve/Date
SS = Split Spoon	trace	0 to 5%			
ST = Shelby Tube	few	5 to 10%			
R = Rock Core	little	15 to 25%	Cohesionless Density: 0-4 Very Loose	Cohesive Consistenc 0-2 Very Soft	
= Lab Sample	some	30 to 45%	5-9 Loose 10-29 Med. Dense	3-4 Soft, 5-8 M/Stiff, 9-15 Stiff	
	mostly	>50%	30-49 Dense 50+ Very Dense	16-30 V-Stiff, 31+ Hard	

AECOM

GEOLOGIC LOG

AECOM

PROJECT : Town of Orelans, MA Preliminary Investigation		SHEET 4 of 4	BORING NO. MW-E6-A
SITE LOCATION: Orleans, MA	JOB NO.:		
Groundwater Discharge Beds	LOCATION: Town of Orleans Landfill N: E:	Elevation:	Total Depth: 60 ft
DRILL CONTRACTOR : NE Geotech	ENG/GEO : John Shannon	BEGUN : 1/21/16 7:30 AM	
DRILL RIG :	DRILLER : NE Geotech - Hayes	FINISHED : 1/21/16 2:00 PM	
Hole Size: 2 inch	Weather : Overcast and cold, High 40, low 32.	Ground Water (Date/Depth): Jan 21, 2016 / 55 f	
Drilling Method :	Drilling Fluid :	Top of Rock (Depth/Elev.) :	

Depth (ft)	Sample Type/No.	N Value	Blow Count (per 6 in.) or Drilling Rate(min/ft)	Sample Recovery or REC & RQD	SAMPLE DESCRIPTION	ASTM CLASS	GENERALIZED STRATIGRAPHIC DESCRIPTION *(dashed where inferred)*
45					60-75 ft. not sampled		
50							
55					(bottom of boring)		

Sample Types:			SPT Resistance		Approve/Date
SS = Split Spoon	trace	0 to 5%			
ST = Shelby Tube	few	5 to 10%			
R = Rock Core	little	15 to 25%	Cohesionless Density: 0-4 Very Loose	Cohesive Consistenc 0-2 Very Soft	
= Lab Sample	some	30 to 45%	5-9 Loose 10-29 Med. Dense	3-4 Soft, 5-8 M/Stiff, 9-15 Stiff	
	mostly	>50%	30-49 Dense 50+ Very Dense	16-30 V-Stiff, 31+ Hard	

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GEOLOGIC LOG

PROJECT : Town of Orelans, MA Preliminary Investigation		SHEET 1 of 3	BORING NO. MW-G1-A
SITE LOCATION: Orleans, MA	JOB NO.:		
Groundwater Discharge Beds	LOCATION: Asa's Landing at Gibson Rd, Orleans, MA N: E:	Elevation:	Total Depth: 45
DRILL CONTRACTOR : NE Geotech	ENG/GEO : John Shannon	BEGUN : 1/20/16 1:00 PM	
DRILL RIG :	DRILLER : NE Geotech - Hayes	FINISHED : 1/20/16 3:00 PM	
Hole Size: 2 inch	Weather : Sunny. High 31, low 23. Winds WNW at 15 to 25 mp	Ground Water (Date/Depth): Jan 20, 2016 / 23 f	
Drilling Method :	Drilling Fluid :	Top of Rock (Depth/Elev.) :	

Depth (ft)	Sample Type/No.	N Value	Blow Count (per 6 in.) or Drilling Rate(min/ft)	Sample Recovery or REC & RQD	SAMPLE DESCRIPTION	ASTM CLASS	GENERALIZED STRATIGRAPHIC DESCRIPTION *(dashed where inferred)*
					0-5 ft - Vacum truck soft drilling of first 5 feet. Spoils used as backfill		2" well screen from 45' to 35'
5							
					5-11 ft. lt. brown to tan, very coarse to medium SAND with trace silt and gravel		
10							
					11-31 ft. tan to light brown to reddish brown, very coarse to coarse SAND with trace silt		
15							
					(continued)		

Sample Types:			SPT Resistance		Approve/Date
SS = Split Spoon	trace	0 to 5%			
ST = Shelby Tube	few	5 to 10%			
R = Rock Core	little	15 to 25%	Cohesionless Density: 0-4 Very Loose	Cohesive Consistenc 0-2 Very Soft	
= Lab Sample	some	30 to 45%	5-9 Loose 10-29 Med. Dense	3-4 Soft, 5-8 M/Stiff, 9-15 Stiff	
	mostly	>50%	30-49 Dense 50+ Very Dense	16-30 V-Stiff, 31+ Hard	

AECOM

GEOLOGIC LOG

PROJECT : Town of Orelans, MA Preliminary Investigation		SHEET	BORING NO.
SITE LOCATION: Orleans, MA	JOB NO.:	2 of 3	MW-G1-A
Groundwater Discharge Beds	LOCATION: Asa's Landing at Gibson Rd, Orleans, MA N: E:	Elevation:	Total Depth: 45
DRILL CONTRACTOR : NE Geotech	ENG/GEO : John Shannon	BEGUN :	1/20/16 1:00 PM
DRILL RIG :	DRILLER : NE Geotech - Hayes	FINISHED :	1/20/16 3:00 PM
Hole Size: 2 inch	Weather : Sunny. High 31, low 23. Winds WNW at 15 to 25 mp	Ground Water (Date/Depth): Jan 20, 2016 / 23 f	
Drilling Method :	Drilling Fluid :	Top of Rock (Depth/Elev.) :	

Depth (ft)	Sample Type/No.	N Value	Blow Count (per 6 in.) or Drilling Rate(min/ft)	Sample Recovery or REC & RQD	SAMPLE DESCRIPTION	ASTM CLASS	GENERALIZED STRATIGRAPHIC DESCRIPTION *(dashed where inferred)*
					(continued)		
					11-31 ft. tan to light brown to reddish brown, very coarse to coarse SAND with trace silt		
25							
30							
					31-32 ft. gray to light tan, SILT and CLAY		
					32-32.5 ft. reddish brown, coarse SAND		
					32.5-33 ft. gray to light tan, SILT and CLAY		
35					33-35 ft. tan to reddish brown, very coarse SAND with some gravel.		
					35-37 ft. brown to reddish brown, GRAVEL		
					37-39.5 ft. tan to light brown, fine SAND with some silt		
					39.5-40 ft. tan to gray, SILT and CLAY		

Sample Types:			SPT Resistance		Approve/Date
SS = Split Spoon	trace	0 to 5%			
ST = Shelby Tube	few	5 to 10%			
R = Rock Core	little	15 to 25%	Cohesionless Density: 0-4 Very Loose	Cohesive Consistenc 0-2 Very Soft	
= Lab Sample	some	30 to 45%	5-9 Loose 10-29 Med. Dense	3-4 Soft, 5-8 M/Stiff, 9-15 Stiff	
	mostly	>50%	30-49 Dense 50+ Very Dense	16-30 V-Stiff, 31+ Hard	

GEOLOGIC LOG

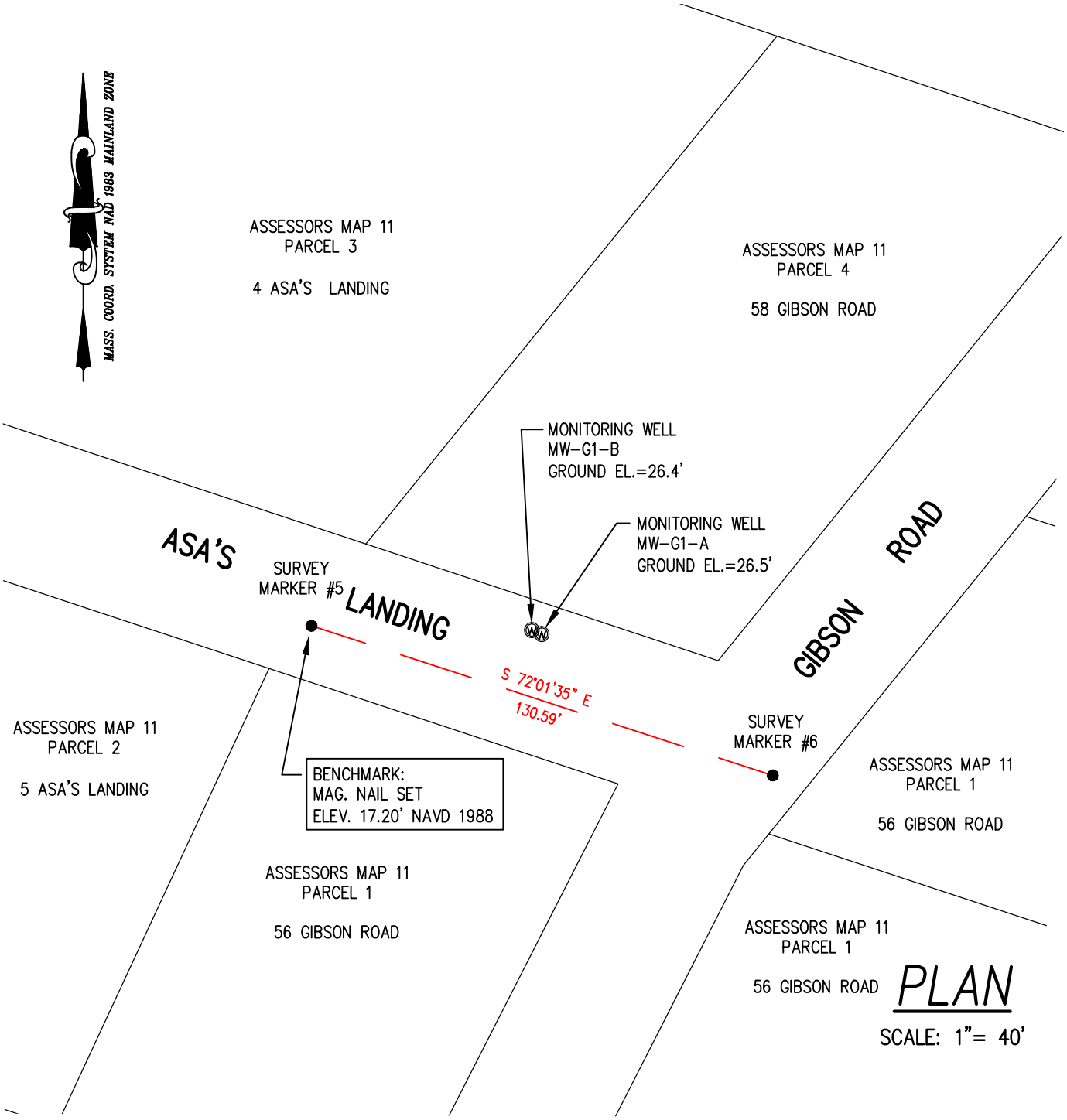
AECOM

PROJECT : Town of Orelans, MA Preliminary Investigation		SHEET	BORING NO.
SITE LOCATION: Orleans, MA	JOB NO.:	3 of 3	MW-G1-A
Groundwater Discharge Beds	LOCATION: Asa's Landing at Gibson Rd, Orleans, MA N: E:	Elevation:	Total Depth: 45
DRILL CONTRACTOR : NE Geotech	ENG/GEO : John Shannon	BEGUN :	1/20/16 1:00 PM
DRILL RIG :	DRILLER : NE Geotech - Hayes	FINISHED :	1/20/16 3:00 PM
Hole Size: 2 inch	Weather : Sunny. High 31, low 23. Winds WNW at 15 to 25 mp	Ground Water (Date/Depth): Jan 20, 2016 / 23 f	
Drilling Method :	Drilling Fluid :	Top of Rock (Depth/Elev.) :	

Depth (ft)	Sample Type/No.	N Value	Blow Count (per 6 in.) or Drilling Rate(min/ft)	Sample Recovery or REC & RQD	SAMPLE DESCRIPTION	ASTM CLASS	GENERALIZED STRATIGRAPHIC DESCRIPTION *(dashed where inferred)*
					40-44 ft. light brown to reddish brown, coarse to medium SAND with trace silt		
45					44-45 ft. reddish brown, GRAVEL		
					(bottom of boring)		
50							
55							

Sample Types:			SPT Resistance		Approve/Date
SS = Split Spoon	trace	0 to 5%			
ST = Shelby Tube	few	5 to 10%			
R = Rock Core	little	15 to 25%	Cohesionless Density: 0-4 Very Loose	Cohesive Consistenc 0-2 Very Soft	
= Lab Sample	some	30 to 45%	5-9 Loose 10-29 Med. Dense	3-4 Soft, 5-8 M/Stiff, 9-15 Stiff	
	mostly	>50%	30-49 Dense 50+ Very Dense	16-30 V-Stiff, 31+ Hard	

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PLAN

SCALE: 1"= 40'

Point	Northing	Easting	Elevation	Description
MW-G1-A	2755701.659	1073065.630	26.31	TOP OF PIPE
MW-G1-B	2755702.721	1073062.972	25.99	TOP OF PIPE
SM-5	2755703.929	1073003.658	17.20	MAG NAIL
SM-6	2755663.631	1073127.874	28.91	MAG NAIL

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C18470-00.dwg

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260 Cranberry Hwy. Orleans, MA 02653
508.255.6511 P 508.255.6700 F

WELL PLAN OF LAND
FOR
AECOM
ORLEANS, MA

GIBSON ROAD

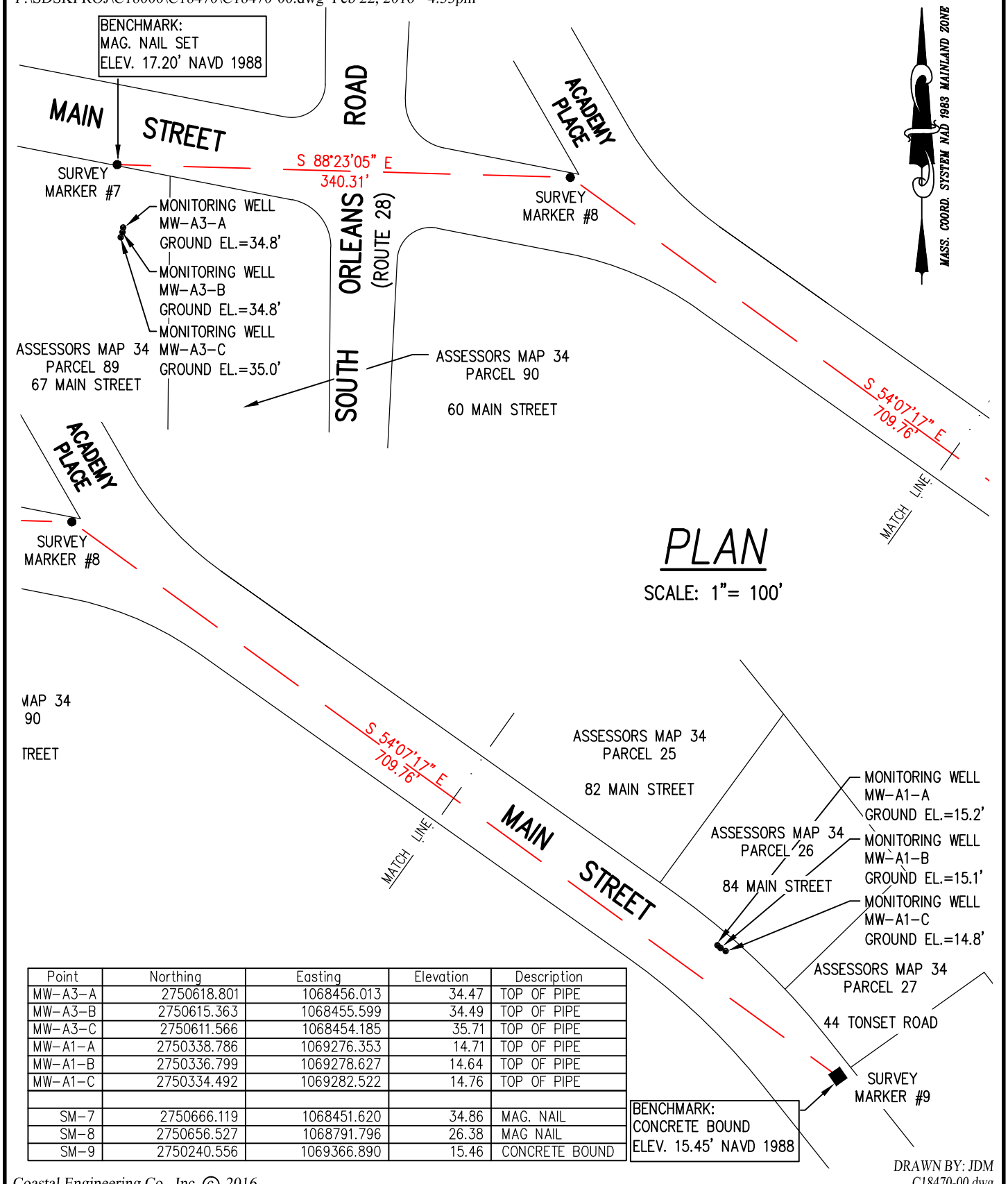
SHEET NO.
SKC-2

PROJECT NO.
C18470.00

SCALE
1"=40'

DATE
2/5/2016

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Point	Northing	Easting	Elevation	Description
MW-A3-A	2750618.801	1068456.013	34.47	TOP OF PIPE
MW-A3-B	2750615.363	1068455.599	34.49	TOP OF PIPE
MW-A3-C	2750611.566	1068454.185	35.71	TOP OF PIPE
MW-A1-A	2750338.786	1069276.353	14.71	TOP OF PIPE
MW-A1-B	2750336.799	1069278.627	14.64	TOP OF PIPE
MW-A1-C	2750334.492	1069282.522	14.76	TOP OF PIPE
SM-7	2750666.119	1068451.620	34.86	MAG. NAIL
SM-8	2750656.527	1068791.796	26.38	MAG NAIL
SM-9	2750240.556	1069366.890	15.46	CONCRETE BOUND

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WELL PLAN OF LAND
FOR
AECOM
ORLEANS, MA
MAIN STREET

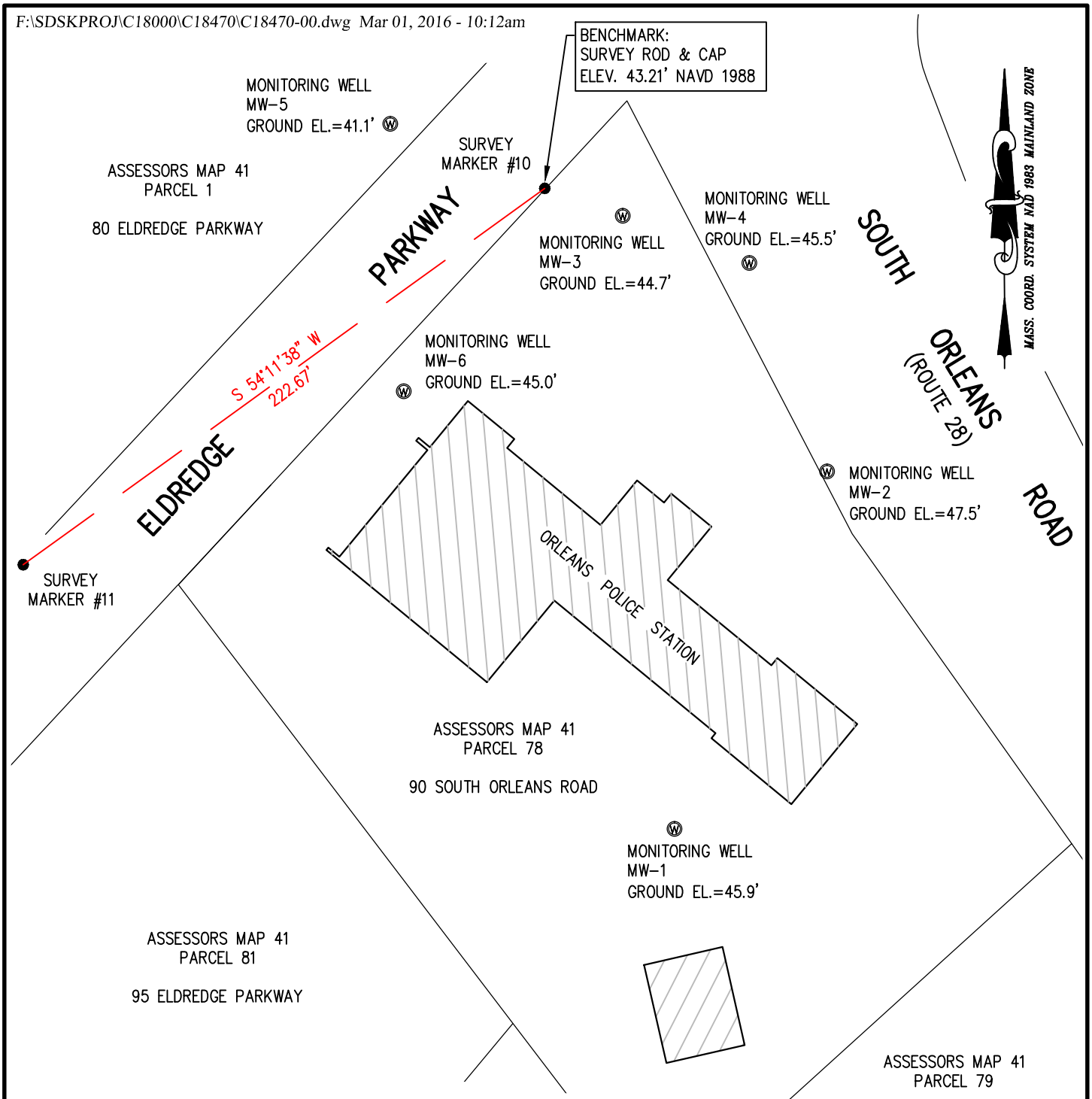
SHEET NO.
SKC-3

PROJECT NO.
C18470.00

SCALE
1"=100'

DATE
2/22/2016

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Point	Northing	Easting	Elevation	Description
MW-1	2748945.614	1068639.865	45.68	TOP OF PIPE
MW-2	2749069.380	1068692.752	46.97	TOP OF PIPE
MW-3	2749157.860	1068622.003	44.20	TOP OF PIPE
MW-4	2749141.510	1068665.766	45.31	TOP OF PIPE
MW-5	2749189.718	1068541.490	40.74	TOP OF PIPE
MW-6	2749097.097	1068546.124	44.77	TOP OF PIPE
SM-10	2749167.373	1068595.011	43.21	REBAR & CAP
SM-11	2749037.101	1068414.426	46.92	REBAR & CAP

PLAN

SCALE: 1"= 50'

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508.255.6511 P 508.255.6700 F

WELL PLAN OF LAND
FOR
AECOM
SOUTH ORLEANS RD. ORLEANS, MA

SHEET NO. SKC-4

PROJECT NO. C18470.00

SCALE 1"=50'

DATE 2/22/2016

Point	Northing	Easting	Elevation	Description
MW-5A	2746928.574	1066059.990	103.93	TOP OF PIPE
MW-5B	2746930.990	1066059.285	103.96	TOP OF PIPE
MW-1A	2746378.251	1065412.230	85.08	TOP OF PIPE
MW-1B	2746376.912	1065411.951	85.18	TOP OF PIPE
MW-E6-A	2746742.487	1065854.917	71.17	TOP OF PIPE
MW-E6-B	2746749.138	1065854.084	71.36	TOP OF PIPE
MW-E6-C	2746753.180	1065853.573	71.50	TOP OF PIPE
MW-2A	2747083.146	1065868.116	101.51	TOP OF PIPE
MW-2B	2747082.250	1065873.604	101.45	TOP OF PIPE
GMW-101	2746649.682	1065865.788	71.31	TOP OF PIPE
GMW-14	2746639.787	1065965.771	70.33	TOP OF PIPE
GMW-102	2746650.013	1066063.232	68.63	TOP OF PIPE
MW-3A	2746610.267	1066103.468	70.31	TOP OF PIPE
MW-3B	2746608.706	1066105.838	69.71	TOP OF PIPE
GMW-103	2746544.806	1066176.910	62.91	TOP OF PIPE
MW-4	2745747.855	1066021.971	105.00	TOP OF PIPE
SM-14	2745856.987	1066048.920	102.64	REBAR & CAP
SM-12	2746524.652	1066017.289	82.35	REBAR & CAP
SM-13	2746634.195	1065606.584	85.16	REBAR & CAP

MONITORING WELL
MW-1B
GROUND EL.=83.2'

MONITORING WELL
MW-1A
GROUND EL.=83.3'

MASS. COORD. SYSTEM NAD 1983 MAINLAND ZONE

LOTS HOLLOW ROAD

SURVEY
MARKER #13

BENCHMARK:
SURVEY ROD & CAP
ELEV. 85.16' NAVD 1988

ASSESSORS MAP 47
PARCEL 83

TOWN OF ORLEANS
TRANSFER STATION

56 LOTS HOLLOW ROAD

N 75°03'57" W
425.06' BASELINE

MONITORING WELL
GMW-101
GROUND EL.=69.8'

MONITORING WELL
MW-E6-A
GROUND EL.=71.7'

MONITORING WELL
MW-E6-B
GROUND EL.=71.8'

MONITORING WELL
MW-E6-C
GROUND EL.=71.9'

MONITORING WELL
MW-2A
GROUND EL.=101.2'

MONITORING WELL
MW-2B
GROUND EL.=101.7'

MONITORING WELL
MW-4
GROUND EL.=103.9'

SURVEY
MARKER #14

SURVEY
MARKER #12

N 02°42'45" W
668.41' BASELINE

MONITORING WELL
GMW-14
GROUND EL.=68.6'

MONITORING WELL
MW-5A
GROUND EL.=101.9'

MONITORING WELL
MW-5B
GROUND EL.=102.0'

MONITORING WELL
MW-3A
GROUND EL.=68.5'

MONITORING WELL
MW-3B
GROUND EL.=68.8'

MONITORING WELL
GMW-102
GROUND EL.=67.2'

ELECTRIC EASEMENT

MONITORING WELL
GMW-12
GROUND EL.=62.2'

ASSESSORS MAP 47
PARCELS 44, 48 & 49
TOWN OF ORLEANS

PLAN
0 25 50 100
1"=100'

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PROJECT NO. C18470.00
SCALE 1"=100'
DATE 3/10/16
SHEET NO. SKC-5

WELL PLAN OF LAND
FOR
AECOM

56 LOTS HOLLOW ROAD
ORLEANS, MA

PROJECT

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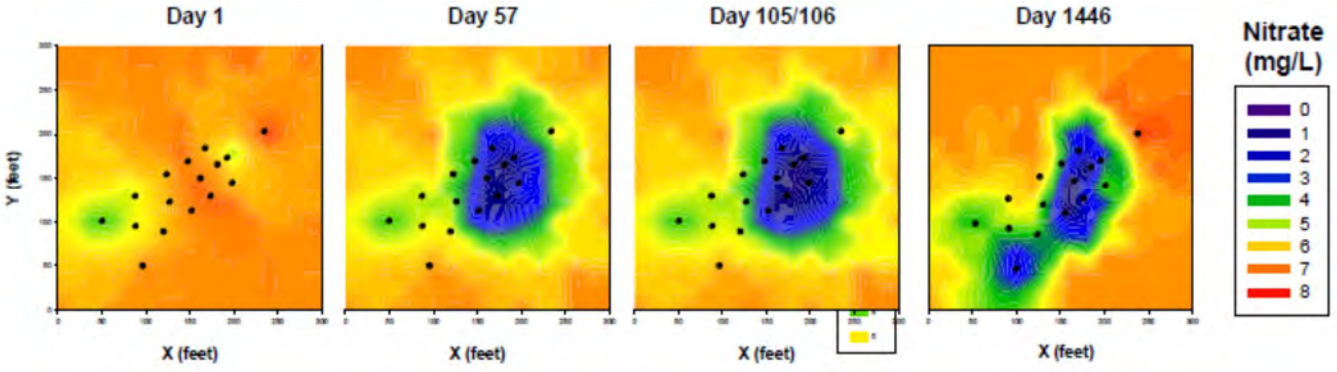
Appendix C

Select AECOM Experience with Anaerobic Bioremediation and Nitrate Reduction

Appendix C – Select AECOM Experience With Anaerobic Bioremediation and Nitrate Reduction

AECOM Explosives Depot Site

AECOM provided investigation, assessment and remediation services on numerous sites at a Department of Defense BRAC facility designated for closure. AECOM conducted bench and field pilot studies to evaluate biologically enhanced reductive treatment of nitrate as well as nitroaromatic and nitroazine explosives in groundwater. Baseline nitrate concentrations ranged between 6 and 15 mg/L. The field pilot studies tested different food-grade carbon amendments and the use of various injection systems (injection wells, direct-push injection). In addition, pilot tests were performed in different areas under a range of groundwater flow conditions. Multiple in-situ biobarriers ranging from 100 to 300 feet in length were established using a grid of injection points. The results of these studies demonstrated the feasibility of in-situ bioremediation of nitrate and explosives in groundwater. High levels of nitrate removal (>99%) were observed, and one area tested showed continued treatment up to 4 years after the initial injection. Both injection wells and direct-push methods were demonstrated to effectively promote in situ treatment of nitrate, including under relatively high flow conditions. The success of the pilot tests led to the development of a bioremediation based exit strategy to facilitate accelerated site closure that will reduce project lifecycle from 100 to about 10 years and with significant life cycle cost reduction compared to pump and treat.

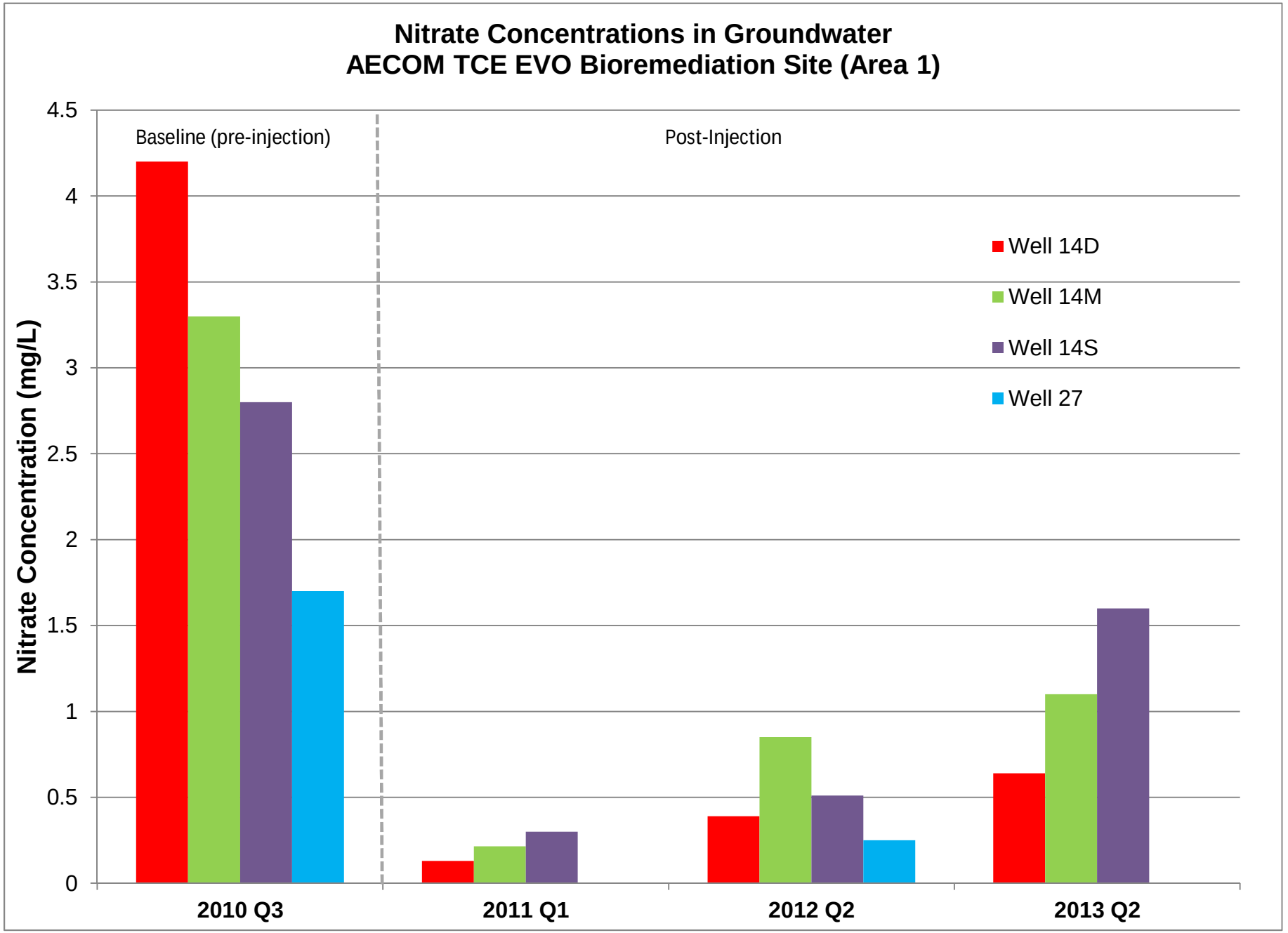


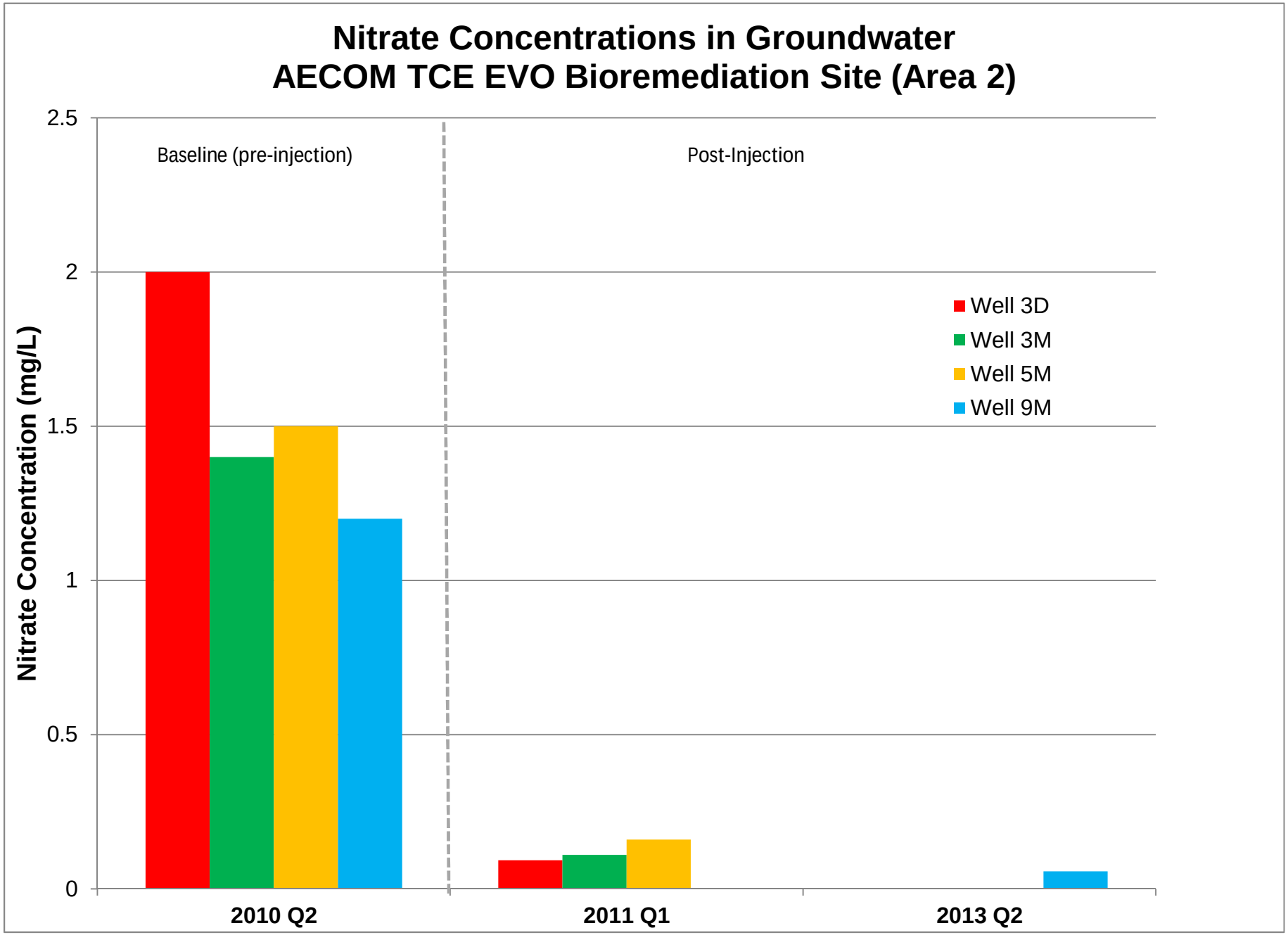
Time series of nitrate concentration after initial injection of food-grade carbon substrate (HRC)

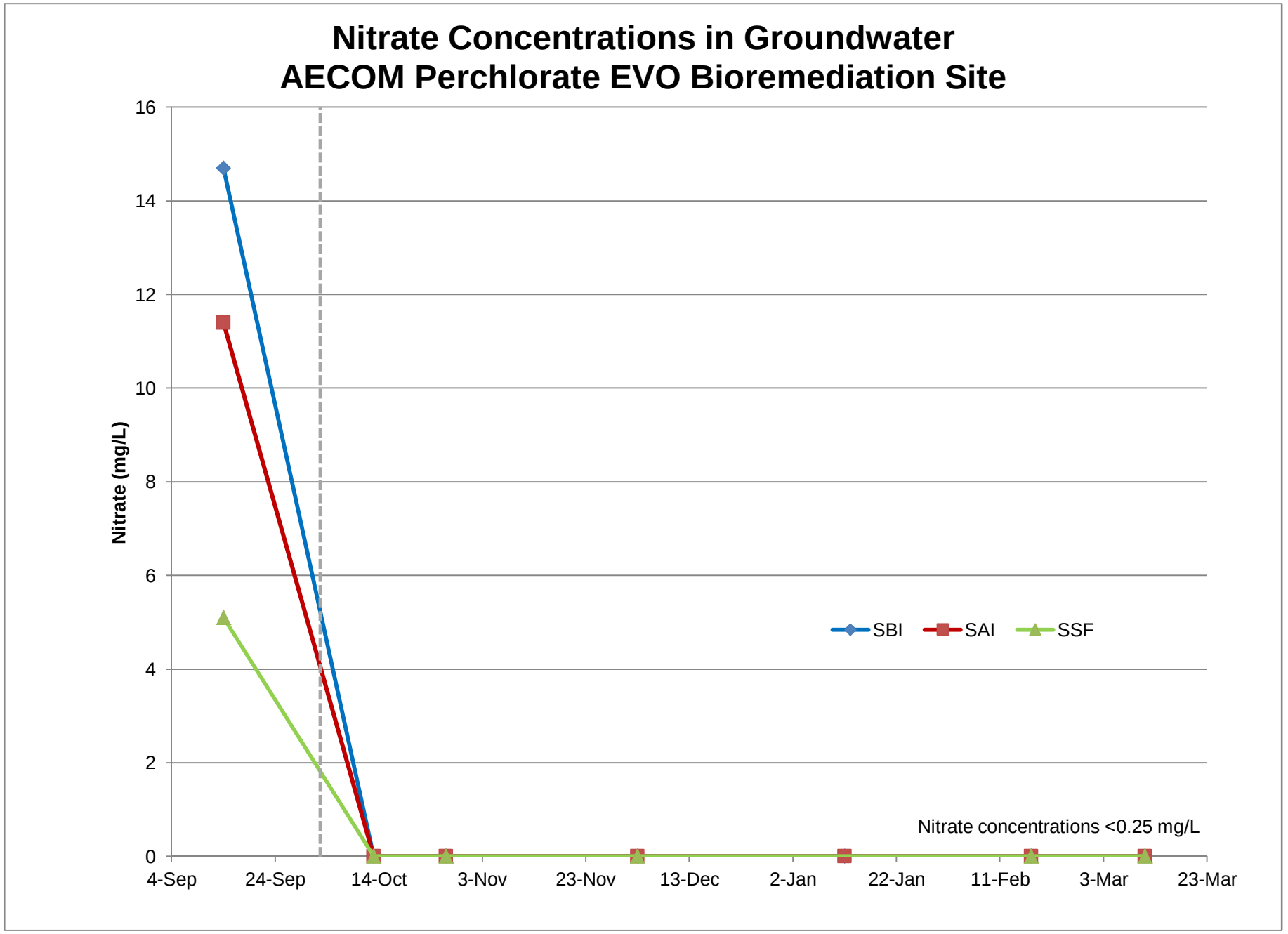
AECOM TCE EVO Bioremediation Site -

Full-scale bioremediation was implemented for treatment of trichloroethene (TCE) in groundwater at a site in New England. Emulsified vegetable oil (EVO) was the selected carbon substrate to enhance anaerobic biodegradation based on results of three pilot tests of multiple carbon substrates in two different areas. Full-scale bioremediation through injection of EVO was performed at two different areas of the site. Nitrate was analyzed for in select monitoring wells and indicated reduction in nitrate concentrations for a period of greater than three years. See pair of bar plots.

AECOM Perchlorate EVO Bioremediation Site- A pilot test was conducted at a Department of Defense facility in California to evaluate in-situ bioremediation for perchlorate in groundwater. EVO was the selected carbon substrate to enhance anaerobic biodegradation. Baseline nitrate concentrations ranged between 5 and 15 mg/L in the pilot test areas. The pilot test monitoring period was only six months, and successful biodegradation of perchlorate was observed. The pilot test monitoring also showed that nitrate was reduced to below detection limits (<0.25 mg/L) within one month of the injection of EVO. See attached line plot.


Nitrate Concentrations in Groundwater
AECOM TCE EVO Bioremediation Site (Area 1)
Nitrate Concentration (mg/L)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Baseline (pre-injection)
Post-Injection
Well 14D
Well 14M
Well 14S
Well 27
2010 Q3
2011 Q1
2012 Q2
2013 Q2


Nitrate Concentrations in Groundwater
AECOM TCE EVO Bioremediation Site (Area 2)
Nitrate Concentration (mg/L)
2.5
2
1.5
1
0.5
0
Baseline (pre-injection)
Post-Injection
Well 3D
Well 3M
Well 5M
Well 9M
2010 Q2
2011 Q1
2013 Q2


Nitrate Concentrations in Groundwater
AECOM Perchlorate EVO Bioremediation Site
Nitrate (mg/L)
16
14
12
10
8
6
4
2
0
4-Sep
24-Sep
14-Oct
3-Nov
23-Nov
13-Dec
2-Jan
22-Jan
11-Feb
3-Mar
23-Mar
SBI
SAI
SSF
Nitrate concentrations <0.25 mg/L

Appendix D

MassDEP Underground Injection Control Registration DRAFT Permit Application (Form BRP WS 06)

Massachusetts Department of Environmental Protection
Bureau of Water Resources – Drinking Water Program

BRP WS 06 UIC Registration

Note: This application form only applies to the following types of Class V UIC wells. This form does not apply to unauthorized wells such as motor vehicle waste disposal wells.

- Motor Vehicle – Rinse Water, Snow/Ice Melt or Rain Drip
- Non-Contact Cooling Water Return Flow
- Subsidence Control
- Aquaculture Return Flow
- Aquifer Recharge/Recovery
- Other
- Saline Water Intrusion Barrier
- Experimental Technology
- Process Water and Wastewater Disposal
- Aquifer Remediation
- Special Drainage – Groundwater Infiltration (Does Not Include Public Water System Wells)
- Special Drainage – Swimming Pools

Refer to the "Instructions and Supporting Materials" document that corresponds to this UIC Registration form for detailed instructions regarding the completion of this form and the required attachments.

Transmittal Number (not required for 1 to 4 unit residential applications) Transmittal #

DRAFT

A. Registration Category & Fee

Registration Category

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.



1. Identify the type of registration activity you are conducting (check one):

   a. Registration of a New or Existing Unregistered UIC Well(s) ☒

   b. Pre-Closure of an Unregistered or Registered UIC Well(s) ☐

   c. Pre-Closure of an Unregistered or Registered UIC Well(s)and Conversion to New Well Type ☐

   Note: Conversion also requires submittal of a separate registration application for the new UIC Class V well type.

   d. Modification of a UIC Registration Application that is Still Under Review at MassDEP ☐

   e. Modification of an Existing UIC Registration that Does Not Include Increasing the Number of Registered Wells ☐

   f. Modification of an Existing UIC Registration that Includes Increasing the Number of Registered Wells ☐

Notes: For the above Pre-Closure categories (items b and c), if you are submitting for a UIC well(s) that has received a MassDEP-issued UIC registration number, complete Sections A, B, L, and M of this application and for all other Sections only complete the data/information fields where you are entering new or revised information. For any of the above Modification categories (items d, e, and f), complete Sections A, B, and M of this application and for all other Sections only complete the data/information fields where you are entering new or revised information.

For Modifications, Pre-Closures, or Pre-Closures and Conversions of a UIC Registered Well:

Enter UIC Registration Number (required): UIC Registration #

BRP WS 06 UIC Registration

A. Registration Category & Fee (cont.)

Basic Well Information

2. Select your Well Category and enter your Well Type (see "Instructions and Supporting Materials Document" for this application form and list of well types from the beginning of this form):

Well Category: Motor Vehicle

☐ Motor Vehicle – Rinse Water, Snow/Ice Melt or Rain Drip

Well Category: Other

☐ Non-Contact Cooling Water Return Flow **with** Additives

☐ Non-Contact Cooling Water Return Flow with **NO** Additives

☐ Subsidence Control

☐ Other

☐ Aquaculture Return Flow

☐ Aquifer Recharge/Recovery

☐ Saline Water Intrusion Barrier

☐ Experimental Technology

☐ Process Water and Wastewater Disposal

☒ Aquifer Remediation

☐ Special Drainage – Groundwater Infiltration (Does Not Include Public Water System Wells)

☐ Special Drainage – Swimming Pools

3. Is the facility serviced by the UIC well(s) **both**:

   a. For four (4) residential units or fewer; and,

   b. Only used for residential purposes? ☐ Yes ☒ No

4. Are any of the wells included in this registration application also being used for another type of UIC Class V discharge? ☐Yes ☒No

5. If you answered "yes" to the above question 4, enter the well category and well type for the other type of discharge (refer to the Class V Injection Well Category, Well Type, and Fee Table in the Instructions):

Well Category _____ Well Type _____

DRAFT

A. Registration Category & Fee (cont.)

UIC Registration Fee

Notes:

For Registration of More than One Type of Discharge – This form may only be used to apply for UIC registration of the well types shown in the table at the top of Page 1. Only one type of UIC discharge (unique well category and well type combination [refer to BRP WS06 forms instructions]) shall be submitted per application form. A separate registration application, payment transmittal form, and applicable fee shall be submitted for each additional type of discharge even if one discharge well is used for more than one well category and well type combination.

For Conversion of Unregistered Wells - If your application is for the conversion of a well(s) that was not previously registered, you shall submit one application form, payment transmittal form, and applicable fee for the registration and closure or partial closure of each of the the unregistered well uses. You shall also submit a separate registration application form, payment transmittal form, and applicable fee for each type of new UIC Class V discharge well.

For Conversion of Registered Wells - If your application is for the conversion of a Registered UIC well(s), you shall submit a separate registration application form, payment transmittal form, and applicable fee for each type of new UIC Class V discharge. In addition one BRP WS06d Pre-Closure application must be submitted for the closure of the previous well use.

Fee Table Instructions

Determine which fee applies to your well(s) using the below fee table in conjunction with the answers you provided for Questions 1 (registration category), 2 (well type), and 3 (residential status).
Step 1: Find the Registration Category in the first row (this will limit the number of columns you have to choose from to either 1 or 2).

Step 2: In the second row find the one column that matches your response to Question 3.

Step 3: Follow this column downward to the row that matches your well category (selected in Question 2).

DRAFT

BRP WS 06 UIC Registration

A. Registration Category & Fee (cont.)

(from question 1 above)

(from question 2 above)

Your Registration Category Selection		**1.a. or 1.f.**		**1.b. or 1.c.**		**1.d. or 1.e.**
Your Answer to Question 3		**Yes**	**No**	**Yes**	**No**	**Yes or No**
Your Well Category	**Your Well Type**					
Motor Vehicle-Related	Motor Vehicle – Rinse Water, Snow/Ice Melt or Rain Drip	$290		$400		$0
Other	Non-Contact Cooling Water Return Flow **with** Additives					
	Subsidence Control					
	Aquaculture Return Flow					
	Saline Water Intrusion Barrier					
	Other					
	Aquifer Recharge/Recovery	$110		$220		
	Non-Contact Cooling Water Return Flow with **NO** additives					
	Experimental Technology	$585		$695		
	Process Water and Wastewater Disposal					
	Aquifer Remediation					
	Special Drainage – Groundwater Infiltration (Does Not Include Public Water System Wells)	$0	$110	$0	$220	
	Special Drainage – Swimming Pools	$0	$290	$0	$400	

DRAFT

Exceptions: If the well is owned by a local or regional government the fee is $0. If the well is owned by the Commonwealth of Massachusetts, the standard fees indicated above apply.

Enter fee here: $585

Annual Compliance Fee: Currently there is no annual compliance fee associated with this Registration.

BRP WS 06 UIC Registration

B. Residential/Facility Information

Town of Orleans
Facility/Residential Property Name

Facility/Residential Street Address

Orleans
City/Town

MA
State

02653
Zip Code

Additional information (for facilities only):

Company Name (if appropriate)

(MassDEP Use Only) Facility #

Facility Public Water Supplier (PWS) ID# (if appropriate)

NAICS or SIC Code # (if applicable)

Facility Telephone Number

Facility Mailing Address (if different from street address)

City/Town

State

Zip Code

EPA Hazardous Waste Generator ID # (if applicable)

EPA Hazardous Waste Generator ID # (if applicable)

Tenant Name (if applicable)

Tenant's EPA Haz. Waste Gen. ID# (if applicable)

C. Current Status of Activity(ies) Being Registered (check one)

☒ Designed, but not yet constructed/modified/closed/converted

☐ Discharge discontinued but closure activities not completed

☐ Proposed activity completed and active or closure completed

☐ Proposed activity partially completed or completed but not active

/ /
Date placed in service (or closure completed)

Is the applicant requesting a waiver of the 30-day waiting period for closure applications?

☐ Yes ☒ No

If you answered "yes" to this question, indicate your reasons for requesting the waiver in a cover letter attached to this application.

D. Owner/Operator Information

Town of Orleans
Name of Owner

19 School Road
Address of Owner (enter "same" if same as facility)

Orleans
City/Town

MA
State

02653
Zip Code

gmeservey@town.orleans.ma.us
Owner Email

Owner's Legal Contact

Legal Contact Phone

Legal Contact Fax #

Name of Operator (if different from owner)

Address of Operator (enter "same" if same as facility)

City/Town

State

Zip Code

Operator Email

Operator's Legal Contact

Legal Contact Phone

Legal Contact Fax #

DRAFT

BRP WS 06 UIC Registration

D. Owner/Operator Information (cont.)

Ownership Type (choose one):

Private: ☐ Industrial ☐ Commercial ☐ Non-profit ☐ Residential

Public: ☒ Local ☐ Regional ☐ State ☐ Federal

E. Designer

Paul M. Dombrowski
Designer's name

AECOM
Name of Company

MA PE 47564
Massachusetts Engineer License Number if applicable)

978-905-2955
Phone number

Paul.Dombrowski2@aecom.com

LSP# (if applicable)

National 3rd party or manufacturer approval and ID number (if applicable)

F. Installer

To Be Determined
Installer's name

Name of Company

National 3rd party or manufacturer approval and ID number (if applicable)

Installer email

Phone number

G. Preparer Information

Paul M. Dombrowski
Preparer name

250 Apollo Drive
Preparer Address

Chelmsford
Preparer City/Town

MA
State

01824
Zip Code

Paul.Dombrowski2@aecom.com
Preparer's email

978-905-2955
Phone number

MA PE 47564
Massachusetts Engineer License Number (if applicable)

LSP# (if applicable)

H. Registered Well Driller (if applicable)

MassDEP Well Driller Registration Number

Well driller's name

Phone number

Name of company Company Reg. #

Well Driller Email

I. Site Information

Water Supply: ☒ Public ☐ Private Sewer: ☐ Public ☒ Private

Other Discharges:

Are there other current or proposed discharges on site? ☐ Yes ☒ No

If yes, are they permitted with MassDEP? ☐ Yes ☐ No
If yes, provide permit #

If no, are they registered with MassDEP as UIC Class V wells? ☐ Yes ☒ No
If yes, provide permit #

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BRP WS 06 UIC Registration

I. Site Information (cont.)

Please list the type or types of other discharges:

Check any of the following that apply to this site:

a. ☐ Bureau of Waste Site Cleanup Priority Site — If yes, file number

b. ☐ Bureau of Waste Site Cleanup Waiver Site — If yes, file number

c. ☐ Superfund site — If yes, Federal ID #

If the site is currently being regulated by the Bureau of Waste Site Cleanup, check any of the following that apply:

☐ Incident Response ☐ Short Term Measure ☐ Activity and Use Limitations (specify):

Confirm that the applicant has checked that the site does not have any activity restrictions with respect to limiting discharges on the site.

☒ No restrictions ☐ Restrictions (Please explain; attach additional sheets if necessary)

Location of Wells

Only enter the location of wells for the one well type you are including in this registration.
Note: Latitude & Longitude are required data. Well ID# is assigned by you and each well should have a unique ID#. Please check the closure box for any well(s) being completely closed to the well category and well type associated with this registration application.
If you need additional well locations, please provide all information on a separate sheet.
If you do not have access to a GPS unit, see instructions to this form for Internet tools that may be used to select well locations.

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BRP WS 06 UIC Registration

I. Site Information (cont.)

Well ID (name and/or number)	Latitude in Decimal Degrees (e.g., 42.355767)	Longitude in Decimal Degrees (e.g., -71.060996)	Check here if well is either being physically closed or if all entry points (discharges) associated with this well category and well type will be discontinued.
			☐
			☐
			☐
			☐
			☐
			☐

Identify the method used for locating the latitude/longitude coordinates for the UIC Class V well(s) (check one):

Location Type (check one):

☐ Approximate location of well

☒ Approximate center of area where discharge is located (i.e. center of drainfield or trench)

Accuracy – Estimated horizontal accuracy is less than (check one):

☒ +/-100 feet ☐ +/- 500 feet ☐ +/- 1,000 feet

Provide a narrative description of the site and the feature to be permitted. As an example: "The site is on the west side of Main Street, the third building north of High Street. The disposal field lies 100 feet off the southwest corner of the building."

Injection points (method to be determined, likely direct-push) for application of solution of carbon substrate (diluted emulsified vegetable oil). Injection points would be spaced approximately 10 feet. In actual permit application description will be provided here for locations at Eldredge Park or Landfill. A separate UIC permit is required for each site.

Attachments:

See instructions for this registration form for more details regarding the necessary attachments. Include the following:

☐ UIC Class V Well Motor Vehicle Rinse Water, Snow/Ice Melt, or Rain Drip Technical Compliance Form and Certification Statement (required for all registrations for this well type unless filing for Pre-Closure of all wells associated with this UIC registration application)

☐ Topographic or Orthophoto Map ☐ Design Sheets ☐ Site Plan (include bar scale)

☒ Existing Analytical Data ☐ Narrative Statement ☐ MSDS Sheets

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BRP WS 06 UIC Registration

I. Site Information (cont.)

☐ Attach Well Completion Report (required for existing drilled wells)

☐ Cross Sectional Diagram Depicting All Underground Components of the UIC System

☐ Other information

J. Injection Well Information

Number of Proposed New Wells	Maximum well depth
Number of Existing Wells	Month/Year of UIC well(s) construction (for existing wells)
Total Number of Existing Plus Proposed Wells	

(do not include wells that are in a different UIC well category and well type (those must be registered under a separate UIC registration number))

Well Construction (check all that apply):

☐ Drywell ☐ Drilled Well ☐ Manufactured System ☐ Dug Well

☐ Improved Sinkhole ☐ Drainfield/Leachfield ☐ Trench Drain ☐ Dustwater onto the ground

☒ Other (describe): Injection means to be determined. Direct push methods will likely be used.

Type of well seal (if applicable)	Well seal grout material

Well Additives: Are any well additives being used or proposed for use? ☒ Yes ☐ No

If you answered yes, attach a completed Proposal for Chemical Use (additive) in a UIC Class V Well supplemental form.

Source of Injection Fluid and Potential Contaminants

Potable water (likely a hydrant)	None
Source of injection fluid #1	Potential contaminants for Source #1
Emulsified vegetable oil	None
Source of injection fluid #2	Potential contaminants for Source #2
Source of injection fluid #3	Potential contaminants for Source #3
Source of injection fluid #4	Potential contaminants for Source #4

Treatment Devices:

If applicable, list any treatment devices prior to the injection point that will serve to remove contaminants from the water that is discharged into the UIC well(s) (attach specification sheets):

Rate of Injection:

Maximum total rate of injection (of all wells combined) (gallons per minute): 50

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J. Injection Well Information (cont.)

Note: If maximum injection rate equals or exceeds 70 gallons per minute (100,000 gallons per day) and the source of the injection is from water withdrawn from a private source of groundwater or surface water, include a Water Management Act Program Form I with your UIC registration application.

Average discharge rate (gallons per day): 7,500

Month/Year ceased using well(s) for previous use(s): n/a

(only applies to wells being closed or converted if applicable)

Number of Entry Points:

Note: the number of entry points equals the number of collection points to the system that are or will be discharging to the Class V UIC well(s). This includes each individual catch basin (including leaching catch basins which are considered both an entry point and a Class V UIC well), floor drain, sink, and process water collection point that discharges to the well.

# of entry points to existing system	Total # of entry points for proposed system (existing plus proposed)

Well Setback Distances and Depths: (All distances must be provided in feet.)

Distance to nearest wetland or water body (enter "NA" if distance is greater than 200 feet)	Distance to nearest septic system (enter "NA" if distance is greater than 200 feet)
Distance to nearest building foundation (existing or proposed) (enter "NA" if distance is greater than 25 feet)	Distance to nearest property line (enter "NA" if distance is greater than 25 feet)
Depth to water table (feet)	Depth to bedrock (feet)

Soil type(s) at site - e.g., fill, sandy till, gravel, sand

Distance to nearest Public Water Supply source (e.g., well or reservoir; enter "NA" if distance is greater than 2,500')	Distance to nearest private drinking water well (existing or proposed) (enter "NA" if distance is greater than 1,250 feet)

K. Additional Well-Type-Specific Information

This section contains several sub-sections of additional well information questions. Complete ONLY the sub-section that applies to your specific Well Type. All other sub-sections within this section should be left blank. If your Well Type is not listed below, leave Section K blank.

Well Type = Aquifer Recharge/Recovery or
Well Type = Saline Water Intrusion Barrier or
Well Type = Subsidence Control:

Is the proposed discharge "uncontaminated water" as defined in 314 CMR 5.00?

☒ Yes ☐ No

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BRP WS 06 UIC Registration

K. Additional Well-Type-Specific Information (cont.)

Well Type = Aquifer Remediation:

What is the proposed use of the well(s)? (Check all that apply)

☐ Pump & Treat ☐ Nutrient Addition ☐ Construction Dewatering

Well Type = Process Water and Wastewater Disposal or
Well Type = Special Drainage – Swimming Pool or
Well Type = Aquaculture Return Flow or
Well Type = Special Drainage – Groundwater Infiltration:

Source of water (check all that apply):

☐ Private well ☐ Surface Water ☒ Public Water Supply ☐ Ground Water

L. Injection Well(s) or Activity(ies) Being Closed

Note: Section L should only be filled in if you are closing a well(s).

Is the closure being required by a federal, state, or local entity? ☐ Yes ☐ No

If yes, which regulatory entity? _____

_____ _____
Contact name for regulatory entity Contact Phone

Number of Wells Being Closed with this Application _____

Will this proposed closure activity result in the complete closure of all wells associated with this registration application or with the existing UIC registration number?

☐ Yes ☐ No

If you answered "no" to the above question, how many wells of this well category and well type will remain after the proposed closure activities have been completed?

_____

Will the closure activities include the closure of one or more floor drains or plumbing alterations to redirect the discharge to a municipal sewer connection or industrial wastewater holding tank (IWHT)?

☐ Yes ☐ No

If you answered yes you shall contact the local plumbing inspector to obtain the necessary plumbing permits/approvals and shall coordinate the scheduling of floor drain closure/plumbing alterations work with the plumbing inspector. You will be required to submit a copy of **Form WS1: Notice of Plumbing Inspector Approval to Seal Floor Drain** with your Post-Closure Notification Form. If applicable you shall also be required to submit copies of applicable municipal approvals for connecting your floor drains to the municipal sewer system or that you have applied for a MassDEP IWHT Certification.

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L. Injection Well(s) or Activity(ies) Being Closed (cont.)

The following three (3) data entry fields are only associated with the well type being registered with this application. Do not include the numbers of entry points associated with any converted new well type (if applicable).

Number of Entry Points to System before closure _____

Number of Entry Points proposed for closure _____

Number of Entry Points to System after closure _____

Proposed or previously completed well closure activities (check all that apply):

☐ Clean out well(s) ☐ Sample fluids/sediments in the bottom of the injection well(s).

☐ Remove well(s) and any contaminated soil

☐ Appropriate disposal of remaining fluids/sediments

☐ Conversion to other Well Category/Type _____ / _____
Well Category/Well Type

Note: a separate UIC registration application (BRP WS06) must be submitted for any conversion to a new well type.

☐ Well and all entry points physically decommissioned

☐ Partial Closure (some but not all entry points eliminated or well(s) still in use for other types of discharge)

☐ Sample fluids/sediments from the area surrounding the injection well(s) (as applicable)

☐ Other: _____

Proposed Laboratory Analytical Parameters for Soil Sampling Activities:

Note: VOCs, VPH, EPH, and metals testing of soils are required for the closure of all motor vehicle wells.

☐ VOCs (EPA method 8260C) ☐ VPH ☐ EPH ☐ Metals (As, Ba, Cd, Cr, Pb, Hg, Ni, Se, Zn)

_____ Other Soil Sampling Parameter
_____ Other Soil Sampling Parameter

_____ Other Soil Sampling Parameter
_____ Other Soil Sampling Parameter

_____ Other Soil Sampling Parameter
_____ Other Soil Sampling Parameter

Proposed Laboratory Analytical Parameters for Groundwater Sampling Activities:

_____ Groundwater Sampling Parameter #1
_____ Groundwater Sampling Parameter #2

_____ Groundwater Sampling Parameter #3
_____ Groundwater Sampling Parameter #4

_____ Groundwater Sampling Parameter #5
_____ Groundwater Sampling Parameter #6

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M. Certifications for UIC Well(s) that is/are Being Registered for Continued Use or Proposed Future Use for the Well Type Activity Selected for this Application

Operator

The injection well(s) described above is used for placement or injection of fluids into the ground. I understand that this well is subject to inventory requirements and compliance with the regulations under the Underground Injection Control Program established pursuant to the Safe Drinking Water Act, P.L. 93-523 and amendments, and UIC guidelines, and I hereby serve notice that the well is proposed or in service.

I agree:

1. That the well(s) described herein will not be used for discharges other than those described above (unless I have applied for and received the required Massachusetts and local government approvals);

2. That I will notify the MassDEP Drinking Water Program/UIC Program (on forms provided by the UIC program) if any of the information (including ownership, location or type of discharge, and installation of additional wells,) for the above well(s) changes, but before the change occurs (30-day minimum notice on ownership/operator and 60-day notice on all other changes) (ownership changes not required after a UIC registration number has been completely closed (i.e. all wells associated with the approved registration application have been closed and closure has been approved by MassDEP));

3. That I will notify the MassDEP Drinking Water Program/UIC Program (on forms provided by the UIC program) if the well(s) become(s) inactive;

4. That I will notify the MassDEP Drinking Water Program/UIC Program (on forms provided by the UIC program) when the above well(s) is no longer in use, but before physically decommissioning the well(s) and that I will file a Post-Closure Notification Form within seven days of completing the closure with the UIC program.

5. That I will maintain financial responsibility for the well described above; and,

6. That I will provide a sampling tap (approved by MassDEP) and allow sampling at the point of injection (not required for a closed well).

I certify under pains and penalties of law that I have personally examined and am familiar with the information submitted in this document and all attachments and based on my personal knowledge or inquiry of those agents immediately responsible for obtaining the information on my behalf, I believe the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including possible fines and imprisonment.

Signature of Operator	Date
Name of Operator	Position/Title

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BRP WS 06 UIC Registration

M. Certifications for UIC Well(s) that is/are Being Registered for Continued Use or Proposed Future Use for the Well Type Activity Selected for this Application (cont.)

Owner (must be completed if owner has not signed above as operator)

I certify that I have personally examined and am familiar with the information submitted in this document and agree to the installation, conversion, or closure of the discharge well(s) described in this application. I also agree that I will assume the responsibilities of the operator in the event that the operator leaves the property and a replacement operator has not been established and reported to MassDEP (on forms provided by the UIC program).

Signature of Owner	Date
Printed Name	Position/Title

N. Certifications for UIC Well(s) that is/are Being Registered for Complete Closure of all Future Activities Associated with the Well Type Selected for this Application

Operator

I certify under pains and penalties of law that I have personally examined and am familiar with the information submitted in this document and all attachments and based on my personal knowledge or inquiry of those agents immediately responsible for obtaining the information on my behalf, I believe the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including possible fines and imprisonment.

Signature of Operator	Date
Name of Operator	Position/Title

Owner (must be completed if owner has not signed above as operator)

I certify that I have personally examined and am familiar with the information submitted in this document and agree to the conversion or closure of the discharge well(s) described in this application.

Signature of Owner	Date
Printed Name	Position/Title

Submit a signed and complete application package to:

MassDEP
Bureau of Resource Protection
UIC Program
One Winter Street, 5th Floor
Boston, MA 02108

Send duplicate copies of this form to:

Local Board of Health
Local Plumbing Inspector (for any applications involving the closure of floor drains or the installation of dual use ground source heat pump wells)

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Appendix E

Emulsified Vegetable Oil Product Information and Material Safety Data Sheet

Terra Systems, Inc.
SRS®-FR Large Droplet Emulsified Vegetable Oil (EVO) Substrate for Fractured Rock Formations
United States Patent No. RE40,448

The anaerobic bioremediation process uses either native or introduced microorganisms to degrade chlorinated solvents such as tetrachloroethene (PCE) and trichloroethene (TCE) to innocuous end products including ethene and ethane. An organic substrate must be added to the groundwater to generate reducing conditions and provide the necessary carbon and hydrogen to support biodegradation of the chlorinated solvents. The organic substrate can be a slow release substrate like Terra Systems' patented small droplet SRS® emulsified vegetable oil substrate. Terra Systems new and patented SRS® -FR, which has a larger droplet size is designed specifically for applications where adherence to the formation is key to making contact with the bacteria. It is designed to release bio-available hydrogen over a period of 3 to 5 years thus enhancing the long-term anaerobic biodegradation of the chlorinated solvents. SRS®-FR optimizes the naturally occurring biodegradation system by supplying the rate limiting factor (in this case hydrogen) in the degradation of CVOC's, certain pesticides/herbicides, perchlorate, and immobilization of certain metals (Cr, As, and some radionucleides).

SRS®-FR Substrate Specifications

Terra Systems, Inc.'s manufacturing facility is configured to allow us to provide our customers with custom blended substrate packages without a cost premium. SRS®-FR package contains the following components:

Ingredient	Percent	SRS®-FR Emulsified Soybean Oil and Sodium Lactate Substrate
Food Grade Soybean Oil	60%	**SRS®-FR** is added to the groundwater to generate reducing conditions and provide the necessary carbon and hydrogen to support biodegradation of chlorinated solvents.
Food Grade Sodium Lactate	4 – 6%	At least 4% sodium lactate to rapidly generate anaerobic conditions.
Food grade Additives/ Preservatives/Proprietary Nutrients	<1%	Proprietary organic and inorganic nutrients such as yeast extract, nitrogen and phosphorus. Organic and inorganic nutrients have been shown to support the growth of the anaerobic microbial population.
Vitamin B_{12}	<1%	At least 25 ppb of Vitamin B_{12}, which has been demonstrated to be an important micronutrient to enhance dechlorination activity. He et al. 2007 investigated the effects of Vitamin B_{12} on reductive dechlorination by *Dehalococcoides*. They found that **25 ppb of Vitamin B_{12}** gave the maximum stimulation of dechlorination.
Proprietary Emulsification Package	4-8%	The proprietary emulsion package combined with the large droplet size allows the soybean oil to adhere to the formation.
Droplet Size	NA	Mean Droplet size of 5 micron

KEY BENEFITS OF SRS®-FR Emulsified Vegetable Oil (EVO) Substrate Include:

- Promotes biodegradation of PCE and TCE to non-toxic end products
- Large droplet size and proprietary emulsion package is ideal for maximum adherence.
- Low cost
- In situ application minimizes site disruptions
- Slow release formula eliminates continuous substrate additions
- SRS®-FR contains only non-toxic food grade materials, which results in green, sustainable remediation
- Can be used as a PRB to cuts off plume migration
- Effective in source zones
- Reduces treatment time from decades to months and years

For more information contact: **Michael Free**
Terra Systems, Inc. 1035 Philadelphia Pike Suite E, Wilmington, DE 19809
(office): (302)798-9553 or (cell) 484-889-2214
e-mail: mfree@terrasystems.net
On the Web@ http:/www.terrasystems.net/

60% LARGE DROPLET SLOW RELEASE EMULSIFIED VEGETABLE OIL SUBSTRATE BUFFERED (SRS®-B) SAFETY DATA SHEET

1. Product Identification

Synonyms:	60% Large Droplet Slow Release Substrate (SRS®-B) Buffered Emulsified Vegetable Oil (EVO)
Recommended Use:	Treatment of groundwater contaminated with chlorinated solvents and other anaerobically degradable compounds.
Supplier:	Terra Systems, Inc. 130 Hickman Road, Suite 1 Claymont, Delaware 19703 Telephone (302) 798-9553 Fax (302) 798-9554 www.terrasystems.net

2. Hazards Identification

Emergency Overview	
Caution:	May cause eye irritation.
Health Rating:	1 - Slight
Flammability Rating:	1 - Slight
Reactivity Rating:	1 - Slight
Contact Rating:	1 - Slight
Protective Equipment:	Goggles; Proper Gloves
Storage Color Code:	Green (General Storage)
Potential Health Effects	
Inhalation:	Not expected to be a health hazard. If heated, may produce vapors or mists that irritate the mucous membranes and cause irritation, dizziness, and nausea. Remove to fresh air. Possible irritant.
Ingestion:	Not expected to be a health hazard via ingestion. Large doses may produce abdominal spasms, diarrhea, or rapid bowel evacuation.
Skin Contact:	No adverse effects expected. May cause irritation or sensitization in sensitive individuals.
Eye Contact:	May cause mild irritation, possible reddening.
Chronic Exposure:	No information found.
Aggravation of Pre-existing Conditions:	No information found.

3. Composition/Information on Ingredients

Ingredient	Synonyms	CAS #	Percent	Hazardous
Soy bean oil	Soya oil	8001-22-7	60%	No
Emulsifiers, lecithin, and proprietary nutrient package containing nitrogen, phosphorus and vitamin B_{12}		Mixture	5 – 15%	No
Sodium lactate	2-hydroxpropionic acid sodium salt	72-17-3	<5%	Yes
Sodium Bicarbonate	Baking soda	144-5-8	<2	No
Magnesium Oxide	Magnesia	1309-48-4	<2	Yes
Water		7732-18-5	20 - 26%	No

The emulsifiers, lecithin, and nutrient package mixture is a trade secret and consists of ingredients of unknown acute toxicity.

4. First Aid Measures

Inhalation: Not expected to require first aid measures. Remove to fresh air. Get medical attention for any breathing difficulty.

Ingestion: If large amounts were swallowed, give water to drink and get medical advice.

Skin Contact: Not expected to require first aid measures. Wash exposed area with soap and water. Get medical advice if irritation develops.

Eye Contact: Immediately flush eyes with plenty of water for at least 15 minutes, lifting upper and lower eyelids occasionally. Get medical attention if irritation persists.

5. Fire Fighting Measures

Fire: Flash point: >200 C (>392 F). Not considered to be a fire hazard. Isolate from heat and open flame.

Explosion: Not considered to be an explosion hazard. Closed containers may explode if exposed to extreme heat.

Fire Extinguishing Media: Dry chemical, foam, or carbon dioxide. Water spray may be ineffective on fire, but can protect fire-fighters and cool closed containers. Use fog nozzles if water is used.

Special Information: In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full face piece operated in the pressure demand or other positive pressure mode.

6. Accidental Release Measures

Clean-up personnel may require protective clothing. Absorb in sand, paper towels, “Oil Dry”, or other inert material. Scoop up and containerize for disposal. Flush trace residues to sewer with soap and water. Containerized waste may be sent to an approved waste disposal facility.

7. Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Containers of this material are not hazardous when empty since they do vapors or harmful substances; observe all warnings and precautions listed for the product. Do not store above 49 C (120 F). Keep container tightly closed and upright when not in use to prevent leakage.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:	None established.
Ventilation System:	Not expected to require any special ventilation.
Personal Respirators (NIOSH Approved):	Not expected to require personal respirator usage.
Skin Protection:	Wear protective gloves and clean body-covering clothing.
Eye Protection:	Use chemical safety goggles and/or a full face shield where splashing is possible. Provide readily accessible eye wash stations and safety showers.
Slips, Trips, and Falls:	Material is slippery when spilled. Clean up with sand, paper towels, “Oil Dry”, or other inert material.

9. Physical and Chemical Properties

Appearance:	White liquid.
Odor:	Vegetable oil.
Solubility:	Miscible in water.
Specific Gravity (water=1):	0.95-0.98. 8.09 pounds per gallon.
pH:	6-9 (40% aqueous solution)
% Volatiles by volume @ 21C (70F):	Negligible.
Boiling Point:	$\geq$ 100C ($\geq$ 212F)
Melting Point:	No information found.
Flash Point (F):	No information found.
Autoignition Temperature:	No information found.
Decomposition Temperature:	No information found.
Vapor Density (Air=1):	No information found.
Vapor Pressure (mm Hg):	< 1.0 @ 20C (68F).
Evaporation Rate (BuAc=1):	No information found.
Viscosity @23 C (73 F):	213 centipoises (1.2 centipoises diluted 1:10)
Partition Coefficient (octanol/water):	No information found.

10. Stability and Reactivity

Stability:	Stable under ordinary conditions of use and storage.
Reactivity:	Not reactive under ordinary conditions.
Hazardous Decomposition Products:	Carbon dioxide and carbon monoxide may form when heated to decomposition.
Hazardous Polymerization:	Will not occur.
Incompatibilities:	Strong oxidizers, acids.
Conditions to Avoid:	Incompatibles. Isolate from heat and open flame.

11. Toxicological Information

Soybean Oil:	No information found on toxicology. It is not a carcinogen listed by IARC, NTP, NIOSH, OSHA, or ACGIH.
Emulsifier/Nutrient Mixture:	No information found on toxicology. It is not a carcinogen listed by IARC, NTP, NIOSH, OSHA, or ACGIH.
Sodium Lactate:	Oral rat LD50: 2,000 mg/kg. 100 mg caused mild irritation to rabbit eye in Draize test. This compound is not listed as a carcinogen by IARC, NRP, NIOSH, OSHA, or ACGIM.
SRS-B:	The toxicity of the mixture has not been measured.

12. Ecological Information

Environmental Fate:	No information found.
Environmental Toxicity:	No information found.
Degradability:	This product is completely biodegradable under both aerobic and anaerobic conditions.
Soil Mobility:	This compound will move with groundwater until the adsorbed onto the soil. Degradation products may be mobile.
Bioaccumulation Potential:	No information found.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Not regulated.

15. Regulatory Information

OSHA STATUS: This product is not hazardous under the criteria of the Federal OSHA hazard Communication Standard 29 CFR 1910.1200. However, thermal processing and decomposition fumes from this product may be hazardous as noted in Section 10.

TSCA STATUS: No component of this product is listed on the TSCA inventory.

CERCLA (Comprehensive Response Compensation, and Liability Act): Not reportable.

SARA TITLE III (Superfund Amendments and Reauthorization Act)
Section 312 Extremely Hazardous Substances: None
Section 311/312 Hazard Categories: Non-hazardous Under Section 311/312
Section 313 Toxic Chemicals: None

RCRA STATUS: If discarded in its purchased form, this product would not be a hazardous waste either by listing or by characteristic. However, under RCRA, it is the responsibility of the product user to determine at the time of disposal, whether a material containing the product or derived from the product should be classified as a hazardous waste. (40 CFR 261.20-24)

CALIFORNIA PROPOSITION 65: The following statement is made in order to comply with the California safe Drinking Water and Toxic Enforcement Act of 1986. The product contains no chemicals known to the State of California to cause cancer.

16. Other Information

NFPA Ratings:	Health: **1** Flammability: **1** Reactivity: **1**
Date Prepared:	June 23, 2014
Revision Information:	SDS Section(s) changed since last revision of document include: None.
Disclaimer:	Terra Systems, Inc. provides the information contained herein in good faith but makes no representation as to its comprehensiveness or accuracy. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person using this product. Individuals receiving the information must exercise their independent judgment in determining its appropriateness for a particular purpose. TERRA SYSTEMS, INC. MAKES NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE INFORMATION SET FORTH HEREIN OR THE PRODUCT TO WHICH THE INFORMATION REFERS. ACCORDINGLY, TERRA SYSTEMS, INC. WILL NOT BE RESPONSIBLE FOR DAMAGES RESULTING FROM USE OF OR RELIANCE UPON THIS INFORMATION.

Prepared by: Terra Systems, Inc.
Phone Number: (302) 798-9553 (U.S.A.)

EOS Remediation, LLC

Experience you can rely on, Products you can trust™

EOS PRO

PRODUCT INFORMATION SHEET

Emulsified Oils Family

Description

EOS PRO (formerly 598B42) is a nutrient-enriched, DoD-validated, food-grade oil/water emulsion designed to quickly stimulate microbial activity while providing long-term nourishment to enhance anaerobic bioremediation of chlorinated solvents, nitrates, perchlorate, energetics, acid mine drainage, and other recalcitrant chemicals in contaminated groundwater. EOS PRO can also be used to reduce redox sensitive metals and radionuclides. The negative surface charges on the droplets combined with small droplet size promote effective transport in the subsurface.

EOS PRO benefits:

- Includes biostimulating vitamins and nutrients
- Rapidly-biodegradable substrates to "jump start" bacterial growth
- Slow release biodegradable substrates to promote long-term biological activity
- Small oil droplet size
- Negative surface charge
- Neutral pH
- Extensive third party validation

EOS PRO incorporates the proven patented EOS® technologies that clients have trusted for more than a decade. Made in the USA with US farmed soybean oil.

Chemical & Physical Properties

Oil Emulsion Concentrate: EOS PRO	**Typical**
Refined and Bleached US Soybean Oil (% by wt.)	59.8
Rapidly Biodegradable Soluble Substrate (% by wt.)	4
Other Organics (emulsifiers, food additives, etc.) (% by wt.) Specific Gravity	10 0.96 - 0.98
pH (Standard Units)	6.0 - 7.0
Median Oil Droplet Size (microns)	1.0
Organic Carbon (% by wt.)	74
Mass of Hydrogen Produced (lbs. H_2 per lb. EOS PRO)	0.25

Packaging

Shipped in 55-gallon drums, 275-gallon IBC totes or bulk tankers (40,000 lbs.)

Handling & Storage

EOS PRO is shipped as a ready-to-use concentrated emulsion that can be diluted with water in the field to prepare a high quality suspension for easy injection. EOS PRO has a low viscosity and can be distributed with commonly available pumps or continuous metering with a diluter (e.g., Dosatron™). Dilution ratios for EOS PRO commonly range from 4:1 to 20:1 (water: EOS PRO) depending on site conditions. EOS PRO injections should be followed with additional chase water to maximize distribution of EOS PRO into the formation.

For best performance, use EOS PRO within 60 days of delivery and store at a temperature between 40°F (4°C) to 100°F (38°C).

Phone: 919.873.2204
Web: www.eosremediation.com

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EOS Remediation, LLC

MATERIAL SAFETY DATA SHEET

EOS PRO, EOS LS, EOS 450, EOS XR

1. MANUFACTUER AND EMERGENCY CONTACT

Manufacturer:

EOS Remediation, LLC
1101 Nowell Road
Raleigh, NC 27607
www.EOSRemediation.com
Phone: 919-873-2204
Fax: 919-873-1074

24-Hour Emergency Contact:

ChemTel Inc.
Phone: 1-800-255-3924
International
Phone: 813-248-0585

Date of Preparation:
January 9, 2013

2. HAZARDOUS INGREDIENTS / IDENTITY INFORMATION

COMPONENT(S)	% by WEIGHT	CAS NO.	EXPOSURE LIMITS		
			OSHA PEL-TWA	ACGIH TLV-TWA	NIOSH REL-TWA
Soybean Oil	45 - 60*	8001-22-7	Mist: 15 mg/m^3 (total) 5 mg/m^3 (respirable)	NE	Mist: 10 mg/m^3 (total) 5 mg/m^3 (respirable)
Emulsifiers Trade Secret [1,2]	1 - 10	Proprietary	NE	NE	NE
Soluble Substrates Trade Secret [1,2]	4 - 8	Proprietary	Mist: 15 mg/m^3 (total) 5 mg/m^3 (respirable)	Mist: 10 mg/m^3	NE
Organic Substrate Trade Secret [1]	0 - 10	Proprietary	NE	Mist: 10 mg/m^3	NE
Food Additives / Preservatives Trade Secret [1]	0.1 - 1	Proprietary	NE	NE	NE
Nutrients / Extracts Trade Secret [1,2]	0 - 1	Proprietary	NE	NE	NE
Water	Balance	7732-18-5	NE	NE	NE

NE - Not established

1 - The precise composition of this product is proprietary information. A more complete disclosure will be provided to a physician in the event of a medical emergency.

2 - The soluble substrates and emulsifiers are generally recognized as safe for food contact.

* - Percentage of soybean oil varies by product.

3. PHYSICAL / CHEMICAL CHARACTERISTICS

pH:	Neutral
Boiling Point:	212°F
Specific Gravity:	0.96-0.98; 0.92 (pure oil phase)
Vapor Pressure:	Not established
Melting Point:	Liquid at room temperature
Percent Volatile by Volume (%):	25 - 48 (as water)
Vapor Density:	Heavier than air
Evaporation Rate:	Not established
Solubility in Water:	Dispersible
Appearance and Odor:	White liquid with vegetable oil odor

4. FIRE AND EXPLOSION HAZARD DATA

Flash Point:	>300°F
Flammable Limits:	Not established
Extinguishing Media:	CO_2, foam, dry chemical Note: Water, fog and foam may cause frothing and spattering.
Special Fire Fighting Procedures:	Wear self-contained breathing apparatus and chemical resistant clothing. Use water spray to cool fire exposed containers.
Unusual Fire Hazards:	Burning will cause oxides of carbon.
Unusual Explosion Hazards:	None

5. REACTIVITY DATA

Stability:	Stable
Incompatibility:	Strong acids and oxidizers
Hazardous Decomposition Products:	Thermal decomposition may produce oxides of carbon.
Hazardous Polymerization:	Will not occur
Conditions to Avoid:	None known

6. HEALTH HAZARD DATA

Routes of Entry:	Ingestion, dermal
Health Hazards:	
Acute:	Potential eye and skin irritant
Chronic:	None known
Carcinogenicity:	
N.T.P:	No
IARC:	No
OSHA:	No
Signs and Symptoms of Exposure:	None known
Medical Conditions Aggravated by Exposure:	None known

Emergency First Aid Procedures:

Inhalation:	Remove to fresh air.
Eyes:	Flush with water for 15 minutes; if irritation persists see a physician.
Skin:	Wash with mild soap and water.
Ingestion:	Product is non-toxic. If nausea occurs, induce vomiting and seek medical attention.

7. PRECAUTIONS FOR SAFE HANDLING AND USE

Handling and Storage:	Do not store near excessive heat or oxidizers.
Other Precautions:	None
Spill Response:	Soak up with dry absorbent and flush area with large amounts of water.
Waste Disposal Methods:	Dispose of according to Federal and local regulations for non-hazardous waste.

8. CONTROL MEASURES

Respiratory Protection:	Not normally required.
Ventilation:	Local exhaust
Protective Gloves:	Recommended
Eye Protection:	Recommended
Other Protective Clothing or Equipment:	None

The information contained herein is based on available data and is believed to be correct. However, EOS Remediation, LLC makes no warranty, expressed or implied, regarding the accuracy of this data or the results to be obtained thereof. This information and product are furnished on the condition that the person receiving them shall make his/her own determination as to the suitability of the product for his/her particular purpose.

Appendix F

Environmental Security Technology Certification Program – Supporting Calculations for EVO Amendment Dosages

SUBSTRATE ESTIMATING TOOL FOR ENHANCED ANAEROBIC BIOREMEDIATION OF CHLORINATED SOLVENTS

Version 1.2
November 2010

Site Data Input Table

TABLE S.1 - INPUT TABLE

Calculation Tables

Table S.2 - Substrate Calculations in Hydrogen

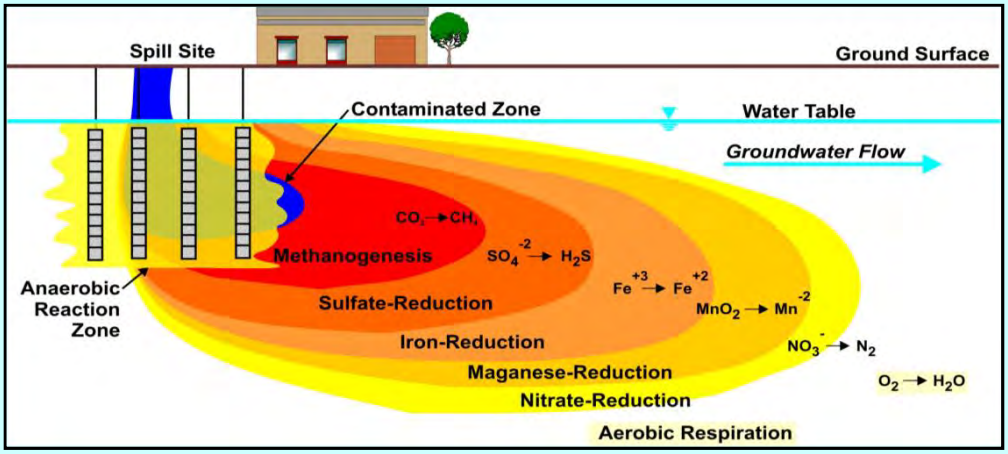
Table S.3 - Hydrogen Produced by Common Substrates

Table S.4 - Estimated Substrate Requirements for

Output Summary Table

TABLE S.5 - OUTPUT TABLE

PRINT SUMMARY TABLE



This Substrate Estimating Tool for Enhanced Anaerobic Bioremediation of Chlorinated Solvents has been developed by Parsons Infrastructure & Technology Group, Inc. (Parsons) for the Environmental Security Technology Certification Program (ESTCP). This substrate estimating tool is made available on an as-is basis without guarantee or warranty of any kind, express or implied. The United States Government, Parsons, the authors, and the reviewers accept no liability resulting from the use of this substrate estimating tool or its documentation; nor does the above warrant or otherwise represent in any way the accuracy, adequacy, efficacy, or applicability of the contents hereof. This substrate estimating tool is intended soley for educational and site screening purposes. Implementation of the substrate estimating tool and interpretation or use of the results provided in the model are the sole responsibility of the user. The substrate estimating tool is provided free of charge for everyone to use, but is not supported in any way by the United States Government or Parsons. Mention of trade names in this report is for information purposes only; no endorsement is implied.

Table S.1 Input for Substrate Requirements in Hydrogen Equivalents

Site Name: PRB Demonstration Test - Landfill

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NOTE: Unshaded boxes are user input.

1. Treatment Zone Physical Dimensions	Values	Range	Units	User Notes
Width (Perpendicular to predominant groundwater flow direction)	50	1-10,000	feet	Focused injection test
Length (Parallel to predominant groundwater flow)	10	1-1,000	feet	PRB orientation, 1 row of injection points
Saturated Thickness	40	1-100	feet	Assumed
Treatment Zone Cross Sectional Area	2000	--	ft^2	
Treatment Zone Volume	20,000	--	ft^3	
Treatment Zone Total Pore Volume (total volume x total porosity)	37,410	--	gallons	
Treatment Zone Effective Pore Volume (total volume x effective porosity)	37,410	--	gallons	
Design Period of Performance	3.0	.5 to 5	year	
Design Factor (times the electron acceptor hydrogen demand)	2.0	2 to 20	unitless	Lower design factor applied for denitrification PRB
2. Treatment Zone Hydrogeologic Properties				
Total Porosity	25%	.05-50	percent	Assumed value for well graded sands
Effective Porosity	25%	.05-50	percent	
Average Aquifer Hydraulic Conductivity	300	.01-1000	ft/day	Estimate from other Cape Cod sites
Average Hydraulic Gradient	0.002	0.0001-0.1	ft/ft	Estimate from other Cape Cod sites
Average Groundwater Seepage Velocity through the Treatment Zone	2.40	--	ft/day	
Average Groundwater Seepage Velocity through the Treatment Zone	876.0	--	ft/yr	
Average Groundwater Discharge through the Treatment Zone	3,277,116	--	gallons/year	
Soil Bulk Density	1.7	1.4-2.0	gm/cm^3	
Soil Fraction Organic Carbon (foc)	0.02%	0.01-10	percent	
3. Native Electron Acceptors				
A. Aqueous-Phase Native Electron Acceptors				
Oxygen	2.0	0.01 to 10	mg/L	Based on AECOM monitoring near gift shop, 2016
Nitrate	30.00	0.1 to- 20	mg/L	Based on monitoring wells near landfill
Sulfate	10	10 to 5,000	mg/L	
Carbon Dioxide (estimated as the amount of Methane produced)	10.0	0.1 to 20	mg/L	
B. Solid-Phase Native Electron Acceptors				
Manganese (IV) (estimated as the amount of Mn (II) produced)	1	0.1 to 20	mg/L	Estimate from other Cape Cod sites
Iron (III) (estimated as the amount of Fe (II) produced)	20	0.1 to 20	mg/L	Estimate from other Cape Cod sites
4. Contaminant Electron Acceptors				
Tetrachloroethene (PCE)	0.000	--	mg/L	no CVOCs assumed
Trichloroethene (TCE)	0.000	--	mg/L	
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	0.000	--	mg/L	
Vinyl Chloride (VC)	0.000	--	mg/L	
Carbon Tetrachloride (CT)	0.000	--	mg/L	
Trichloromethane (or chloroform) (CF)	0.000	--	mg/L	
Dichloromethane (or methylene chloride) (MC)	0.000	--	mg/L	
Chloromethane	0.000	--	mg/L	
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	--	mg/L	
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	--	mg/L	
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	--	mg/L	
Chloroethane	0.000	--	mg/L	
Perchlorate	0.000	--	mg/L	
5. Aquifer Geochemistry (Optional Screening Parameters)				
A. Aqueous Geochemistry				
Oxidation-Reduction Potential (ORP)	150	-400 to +500	mV	Conservative estimate from other Cape Cod sites
Temperature	16	5.0 to 30	ºC	Estimate from other Cape Cod sites
pH	5.8	4.0 to 10.0	su	Based on AECOM monitoring at landfill
Alkalinity	55	10 to 1,000	mg/L	
Total Dissolved Solids (TDS, or salinity)	100	10 to 1,000	mg/L	
Specific Conductivity	850	100 to 10,000	µs/cm	Based on AECOM monitoring at landfill
Chloride	10	10 to 10,000	mg/L	Estimate
Sulfide - Pre injection	0.0	0.1 to 100	mg/L	
Sulfide - Post injection	0.0	0.1 to 100	mg/L	
B. Aquifer Matrix				
Total Iron	10000	200 to 20,000	mg/kg	
Cation Exchange Capacity	NA	1.0 to 10	meq/100 g	
Neutralization Potential	10.0%	1.0 to 100	Percent as $CaCO_3$	

NOTES:

Table S.2 Substrate Calculations in Hydrogen Equivalents

Site Name: PRB Demonstration Test - Landfill

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NOTE: Open cells are user input.

1. Treatment Zone Physical Dimensions

	Values	Range	Units
Width (Perpendicular to predominant groundwater flow direction)	50	1-10,000	feet
Length (Parallel to predominant groundwater flow)	10	1-1,000	feet
Saturated Thickness	40	1-100	feet
Treatment Zone Cross Sectional Area	2000	--	ft^2
Treatment Zone Volume	20,000	--	ft^3
Treatment Zone Effective Pore Volume (total volume x effective porosity)	37,410	--	gallons
Design Period of Performance	3.0	.5 to 5	year

2. Treatment Zone Hydrogeologic Properties

Total Porosity	0.25	.05-50	
Effective Porosity	0.25	.05-50	
Average Aquifer Hydraulic Conductivity	300	.01-1000	ft/day
Average Hydraulic Gradient	0.002	0.1-0.0001	ft/ft
Average Groundwater Seepage Velocity through the Treatment Zone	2.40	--	ft/day
Average Groundwater Seepage Velocity through the Treatment Zone	876.0	--	ft/yr
Average Groundwater Flux through the Treatment Zon 0	3,277,116	--	gallons/year
Soil Bulk Density	1.7	1.4-2.0	gm/cm^3
Soil Fraction Organic Carbon (foc)	0.0002	0.0001-0.1	

3. Initial Treatment Cell Electron-Acceptor Demand (one total pore volume)

A. Aqueous-Phase Native Electron Acceptors	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Oxygen	2.0	0.62	7.94	0.08	4
Nitrate (denitrification)	30.0	9.37	12.30	0.76	5
Sulfate	10	3.12	11.91	0.26	8
Carbon Dioxide (estimated as the amount of methane produced)	10.0	3.12	1.99	1.57	8
Soluble Competing Electron Acceptor Demand (lb.)				**2.67**	

B. Solid-Phase Native Electron Acceptors (Based on manganese and iron produced)	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Manganese (IV) (estimated as the amount of Mn (II) produced)	1.4	115.29	27.25	4.23	2
Iron (III) (estimated as the amount of Fe (II) produced)	20.0	1647.00	55.41	29.72	1
Solid-Phase Competing Electron Acceptor Demand (lb.)				**33.95**	

C. Soluble Contaminant Electron Acceptors	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Tetrachloroethene (PCE)	0.000	0.00	20.57	0.00	8
Trichloroethene (TCE)	0.000	0.00	21.73	0.00	6
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	0.000	0.00	24.05	0.00	4
Vinyl Chloride (VC)	0.000	0.00	31.00	0.00	2
Carbon Tetrachloride (CT)	0.000	0.00	19.08	0.00	8
Trichloromethane (or chloroform) (CF)	0.000	0.00	19.74	0.00	6
Dichloromethane (or methylene chloride) (MC)	0.000	0.00	21.06	0.00	4
Chloromethane	0.000	0.00	25.04	0.00	2
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	0.00	20.82	0.00	8
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	0.00	22.06	0.00	6
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	0.00	24.55	0.00	4
Chloroethane	0.000	0.00	32.00	0.00	2
Perchlorate	0.000	0.00	12.33	0.00	6
Total Soluble Contaminant Electron Acceptor Demand (lb.)				**0.00**	

D. Sorbed Contaminant Electron Acceptors (Soil Concentration = Koc x foc x Cgw)	Koc (mL/g)	Soil Conc. (mg/kg)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Tetrachloroethene (PCE)	263	0.00	0.00	20.57	0.00	8
Trichloroethene (TCE)	107	0.00	0.00	21.73	0.00	6
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	45	0.00	0.00	24.05	0.00	4
Vinyl Chloride (VC)	3.0	0.00	0.00	31.00	0.00	2
Carbon Tetrachloride (CT)	224	0.00	0.00	19.08	0.00	8
Trichloromethane (or chloroform) (CF)	63	0.00	0.00	19.74	0.00	6
Dichloromethane (or methylene chloride) (MC)	28	0.00	0.00	21.06	0.00	4
Chloromethane	25	0.00	0.00	25.04	0.00	2
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	117	0.00	0.00	20.82	0.00	8
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	105	0.00	0.00	22.06	0.00	6
Dichloroethane (1,1-DCA and 1,2-DCA)	30	0.00	0.00	24.55	0.00	4
Chloroethane	3	0.00	0.00	32.00	0.00	2
Perchlorate	0.0	0.00	0.00	12.33	0.00	6
Total Sorbed Contaminant Electron Acceptor Demand (lb.)					**0.00**	

(continued)

Table S.2 Substrate Calculations in Hydrogen Equivalents

4. Treatment Cell Electron-Acceptor Flux (per year)

A. Soluble Native Electron Acceptors	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Oxygen	2.0	54.69	7.94	6.89	4
Nitrate (denitrification)	30.0	820.38	10.25	80.04	5
Sulfate	10	273.46	11.91	22.96	8
Carbon Dioxide (estimated as the amount of Methane produced)	10	273.46	1.99	137.42	8
Total Competing Electron Acceptor Demand Flux (lb/yr)				**247.3**	

B. Soluble Contaminant Electron Acceptors	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Tetrachloroethene (PCE)	0.000	0.00	20.57	0.00	8
Trichloroethene (TCE)	0.000	0.00	21.73	0.00	6
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	0.000	0.00	24.05	0.00	4
Vinyl Chloride (VC)	0.000	0.00	31.00	0.00	2
Carbon Tetrachloride (CT)	0.000	0.00	19.08	0.00	8
Trichloromethane (or chloroform) (CF)	0.000	0.00	19.74	0.00	6
Dichloromethane (or methylene chloride) (MC)	0.000	0.00	21.06	0.00	4
Chloromethane	0.000	0.00	25.04	0.00	2
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	0.00	20.82	0.00	8
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	0.00	22.06	0.00	6
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	0.00	24.55	0.00	4
Chloroethane	0.000	0.00	32.00	0.00	2
Perchlorate	0.000	0.00	12.33	0.00	6
Total Soluble Contaminant Electron Acceptor Demand Flux (lb/yr)				**0.00**	

Initial Hydrogen Requirement First Year (lb)	**283.9**
Total Life-Cycle Hydrogen Requirement (lb)	**778.5**

5. Design Factors

Microbial Efficiency Uncertainty Factor	2X - 4X
Methane and Solid-Phase Electron Acceptor Uncertainty	2X - 4X
Remedial Design Factor (e.g., Substrate Leaving Reaction Zone)	1X - 3X
Design Factor	**2.0**
Total Life-Cycle Hydrogen Requirement with Design Factor (lb)	**1,557.1**

6. Acronyns and Abbreviations

°C =degrees celsius
µs/cm = microsiemens per centimeter
cm/day = centimeters per day
cm/sec = centimeters per second
ft^2 = square feet
ft/day = feet per day
ft/ft = foot per foot
ft/yr = feet per year
gm/cm^3 = grams per cubic centimeter
kg of CaCO3 per mg = kilograms of calcium carbonate per milligram
lb = pounds
meq/100 g = milliequivalents per 100 grams
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
m/m = meters per meters
mV = millivolts
m/yr = meters per year
su = standard pH units
wt/wt H2 = concetration molecular hydrogen, weight per weight

Table S.3

Hydrogen Produced by Fermentation Reactions of Common Substrates

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Substrate	Molecular Formula	Substrate Molecular Weight (gm/mole)	Moles of Hydrogen Produced per Mole of Substrate	Ratio of Hydrogen Produced to Substrate (gm/gm)	Range of Moles H_2/Mole Substrate
Lactic Acid	$C_3H_6O_3$	90.1	2	0.0448	**2 to 3**
Molasses (assuming 100% sucrose)	$C_{12}H_{22}O_{11}$	342	8	0.0471	**8 to 11**
High Fructose Corn Syrup (assuming 50% fructose and 50% glucose)	$C_6H_{12}O_6$	180	4	0.0448	**4 to 6**
Ethanol	C_2H_6O	46.1	2	0.0875	**2 to 6**
Whey (assuming 100% lactose)	$C_{12}H_{22}O_{11}$	342	11	0.0648	**11**
HRC® (assumes 40% lactic acid and 40% glycerol by weight)	$C_{39}H_{56}O_{39}$	956	28	0.0590	**28**
Linoleic Acid (Soybean Oil, Corn Oil, Cotton Oil)	$C_{18}H_{32}O_2$	281	16	0.1150	**16**

Table S.4
Estimated Substrate Requirements for Hydrogen Demand in Table S.3

Design Life (years): 3

Substrate	Design Factor	Pure Substrate Mass Required to Fulfill Hydrogen Demand (pounds)	Substrate Product Required to Fulfill Hydrogen Demand (pounds)	Substrate Mass Required to Fulfill Hydrogen Demand (milligrams)	Effective Substrate Concentration (mg/L)
Lactic Acid	2.0	34,787	34,787	1.58E+10	422
Sodium Lactate Product (60 percent solution)	2.0	34,787	72,172	1.58E+10	422
Molasses (assuming 6 0	2.0	33,047	55,079	1.50E+10	401
HFCS (assuming 40% fructose and 40% glucose by weight)	2.0	34,795	43,493	1.58E+10	422
Ethanol Product (assuming 80% ethanol by weight)	2.0	17,791	22,239	8.07E+09	216
Whey (assuming 100% lactose)	2.0	24,013	34,305	1.09E+10	292
HRC® (assumes 40% lactic acid and 40% glycerol by weight)	2.0	26,370	26,370	1.20E+10	256
Linoleic Acid (Soybean Oil, Corn Oil, Cotton Oil)	2.0	13,540	13,540	6.14E+09	164
Commercial Vegetable Oil Emulsion Product (60% oil by weight)	2.0	13,540	22,567	6.14E+09	164

NOTES: Sodium Lactate Product

1. Assumes sodium lactate product is 60 percent sodium lactate by weight.
2. Molecular weight of sodium lactate (CH_3-CHOH-COONa) = 112.06.
3. Molecular weight of lactic Acid ($C_6H_6O_3$) = 90.08 .
4. Therefore, sodium lactate product yields 48.4 (0.60 x (90.08/112.06)) percent by weight lactic acid.
5. Weight of sodium lactate product = 11.0 pounds per gallon.
6. Pounds per gallon of lactic acid in product = 1.323 x 8.33 lb/gal H2O x 0.60 x (90.08/112.06) = 5.31 lb/gal.

NOTES: Standard HRC Product

1. Assumes HRC product is 40 percent lactic acid and 40 percent glycerol by weight.
2. HRC® weighs approximately 9.18 pounds per gallon.

NOTES: Vegetable Oil Emulsion Product

1. Assumes emulsion product is 60 percent soybean oil by weight.
2. Soybean oil is 7.8 pounds per gallon.
3. Assumes specific gravity of emulsion product is 0.96.

Table S.5 Output for Substrate Requirements in Hydrogen Equivalents

Site Name: PRB Demonstration Test - Landfill

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1. Treatment Zone Physical Dimensions

	Values	Units	Values	Units
Width (perpendicular to groundwater flow)	50	feet	15	meters
Length (parallel to groundwater flow)	10	feet	3.0	meters
Saturated Thickness	40	feet	12.2	meters
Design Period of Performance	3	years	3	years

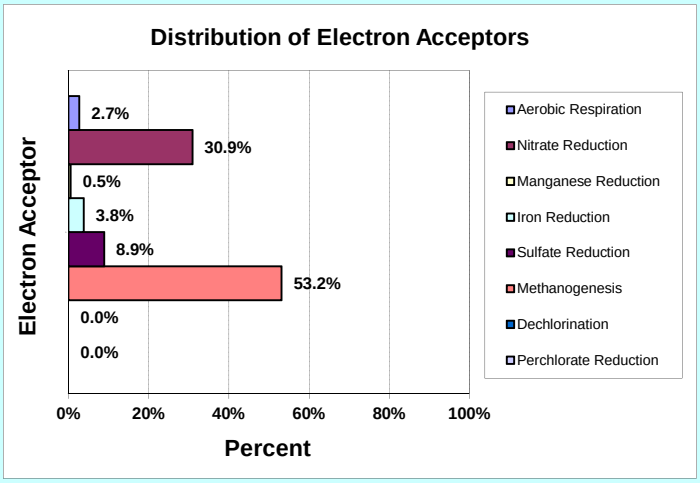
2. Treatment Zone Hydrogeologic Properties

	Values	Units	Values	Units
Total Porosity	0.25	percent	0.25	percent
Effective Porosity	0.25	percent	0.25	percent
Average Aquifer Hydraulic Conductivity	300	ft/day	1.1E-01	cm/sec
Average Hydraulic Gradient	0.002	ft/ft	0.002	m/m
Average Groundwater Seepage Velocity	2.40	ft/day	7.3E+01	cm/day
Average Groundwater Seepage Velocity	876	ft/yr	267.0	m/yr
Effective Treatment Zone Pore Volume	37,410	gallons	141,608	liters
Groundwater Flux (per year)	3,277,116	gallons/year	12,404,887	liters/year
Total Groundwater Volume Treated (over entire design period)	9,868,758	gallons total	37,356,269	liters total

3. Distribution of Electron Acceptor Demand

	Percent of Total	Hydrogen Demand (lb)
Aerobic Respiration	2.7%	20.743
Nitrate Reduction	30.9%	240.873
Sulfate Reduction	8.9%	69.144
Manganese Reduction	0.5%	4.231
Iron Reduction	3.8%	29.724
Methanogenesis	53.2%	413.820
Dechlorination	0.0%	0.000
Perchlorate Reduction	0.0%	0.000
Totals:	**100.00%**	**778.53**

Hydrogen demand in pounds/gallon:	7.89E-05
Hydrogen demand in grams per liter:	9.45E-03



4. Substrate Equivalents: Design Factor = 2.0

Product	Quantity (lb)	Quantity (gallons)	Effective Concentration (mg/L)	Effective concentration is for total volume of groundwater treated.
1. Sodium Lactate Product	72,172	6,561	422	as lactic acid
2. Molasses Product	55,079	4,590	401	as sucrose
3. Fructose Product	43,493	3,883	422	as fructose
4. Ethanol Product	22,239	3,223	216	as ethanol
5. Sweet Dry Whey (lactose)	34,305	sold by pound	292	as lactose
6. HRC®	26,370	sold by pound	256	as 40% lactic acid/40% glycerol
7. Linoleic Acid (Soybean Oil)	13,540	1,736	164	as soybean oil
8. Emulsified Vegetable Oil	22,567	2,893	164	as soybean oil

Notes:

1. Quantity assumes product is 60% sodium lactate by weight.
2. Quantity assumes product is 60% sucrose by weight and weighs 12 pounds per gallon.
3. Quantity assumes product is 80% fructose by weight and weighs 11.2 pounds per gallon.
4. Quantity assumes product is 80% ethanol by weight and weighs 6.9 pounds per gallon.
5. Quantity assumes product is 70% lactose by weight.
6. Quantity assumes HRC® is 40% lactic acid and 40% glycerol by weight.
7. Quantity of neat soybean oil, corn oil, or canola oil.
8. Quantity assumes commercial product is 60% soybean oil by weight.

SUBSTRATE ESTIMATING TOOL FOR ENHANCED ANAEROBIC BIOREMEDIATION OF CHLORINATED SOLVENTS

Version 1.2
November 2010

Site Data Input Table

TABLE S.1 - INPUT TABLE

Calculation Tables

Table S.2 - Substrate Calculations in Hydrogen

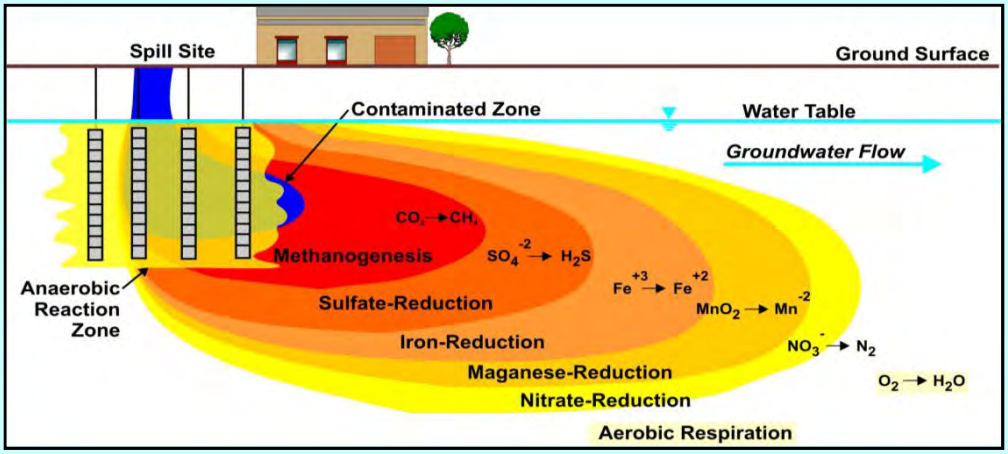
Table S.3 - Hydrogen Produced by Common Substrates

Table S.4 - Estimated Substrate Requirements for

Output Summary Table

TABLE S.5 - OUTPUT TABLE

PRINT SUMMARY TABLE



This Substrate Estimating Tool for Enhanced Anaerobic Bioremediation of Chlorinated Solvents has been developed by Parsons Infrastructure & Technology Group, Inc. (Parsons) for the Environmental Security Technology Certification Program (ESTCP). This substrate estimating tool is made available on an as-is basis without guarantee or warranty of any kind, express or implied. The United States Government, Parsons, the authors, and the reviewers accept no liability resulting from the use of this substrate estimating tool or its documentation; nor does the above warrant or otherwise represent in any way the accuracy, adequacy, efficacy, or applicability of the contents hereof. This substrate estimating tool is intended soley for educational and site screening purposes. Implementation of the substrate estimating tool and interpretation or use of the results provided in the model are the sole responsibility of the user. The substrate estimating tool is provided free of charge for everyone to use, but is not supported in any way by the United States Government or Parsons. Mention of trade names in this report is for information purposes only; no endorsement is implied.

Table S.1 Input for Substrate Requirements in Hydrogen Equivalents

Site Name: PRB Demonstration Test - Site B

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NOTE: Unshaded boxes are user input.

1. Treatment Zone Physical Dimensions	Values	Range	Units	User Notes
Width (Perpendicular to predominant groundwater flow direction)	200	1-10,000	feet	
Length (Parallel to predominant groundwater flow)	10	1-1,000	feet	PRB orientation, 1 row of injection points
Saturated Thickness	40	1-100	feet	Assumed
Treatment Zone Cross Sectional Area	8000	--	ft^2	
Treatment Zone Volume	80,000	--	ft^3	
Treatment Zone Total Pore Volume (total volume x total porosity)	149,640	--	gallons	
Treatment Zone Effective Pore Volume (total volume x effective porosity)	149,640	--	gallons	
Design Period of Performance	3.0	.5 to 5	year	
Design Factor (times the electron acceptor hydrogen demand)	2.0	2 to 20	unitless	Lower design factor applied for denitrification PRB
2. Treatment Zone Hydrogeologic Properties				
Total Porosity	25%	.05-50	percent	Assumed value for well graded sands
Effective Porosity	25%	.05-50	percent	
Average Aquifer Hydraulic Conductivity	300	.01-1000	ft/day	Estimate from other Cape Cod sites
Average Hydraulic Gradient	0.002	0.0001-0.1	ft/ft	Estimate from other Cape Cod sites
Average Groundwater Seepage Velocity through the Treatment Zone	2.40	--	ft/day	
Average Groundwater Seepage Velocity through the Treatment Zone	876.0	--	ft/yr	
Average Groundwater Discharge through the Treatment Zone	13,108,464	--	gallons/year	
Soil Bulk Density	1.7	1.4-2.0	gm/cm^3	
Soil Fraction Organic Carbon (foc)	0.02%	0.01-10	percent	
3. Native Electron Acceptors				
A. Aqueous-Phase Native Electron Acceptors				
Oxygen	3.0	0.01 to 10	mg/L	Average DO in AECOM wells along Main Street
Nitrate	15.00	0.1 to- 20	mg/L	Max. concentration based on monitoring wells near police station
Sulfate	10	10 to 5,000	mg/L	
Carbon Dioxide (estimated as the amount of Methane produced)	10.0	0.1 to 20	mg/L	
B. Solid-Phase Native Electron Acceptors				
Manganese (IV) (estimated as the amount of Mn (II) produced)	1	0.1 to 20	mg/L	Estimate from other Cape Cod sites
Iron (III) (estimated as the amount of Fe (II) produced)	20	0.1 to 20	mg/L	Estimate from other Cape Cod sites
4. Contaminant Electron Acceptors				
Tetrachloroethene (PCE)	0.000	--	mg/L	no CVOCs assumed
Trichloroethene (TCE)	0.000	--	mg/L	
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	0.000	--	mg/L	
Vinyl Chloride (VC)	0.000	--	mg/L	
Carbon Tetrachloride (CT)	0.000	--	mg/L	
Trichloromethane (or chloroform) (CF)	0.000	--	mg/L	
Dichloromethane (or methylene chloride) (MC)	0.000	--	mg/L	
Chloromethane	0.000	--	mg/L	
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	--	mg/L	
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	--	mg/L	
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	--	mg/L	
Chloroethane	0.000	--	mg/L	
Perchlorate	0.000	--	mg/L	
5. Aquifer Geochemistry (Optional Screening Parameters)				
A. Aqueous Geochemistry				
Oxidation-Reduction Potential (ORP)	50	-400 to +500	mV	Based on AECOM monitoring near Main St.
Temperature	16	5.0 to 30	ºC	
pH	5.8	4.0 to 10.0	su	Based on AECOM monitoring near Main St.
Alkalinity	55	10 to 1,000	mg/L	
Total Dissolved Solids (TDS, or salinity)	100	10 to 1,000	mg/L	
Specific Conductivity	650	100 to 10,000	µs/cm	Based on AECOM monitoring near Main St.
Chloride	10	10 to 10,000	mg/L	
Sulfide - Pre injection	0.0	0.1 to 100	mg/L	
Sulfide - Post injection	0.0	0.1 to 100	mg/L	
B. Aquifer Matrix				
Total Iron	10000	200 to 20,000	mg/kg	
Cation Exchange Capacity	NA	1.0 to 10	meq/100 g	
Neutralization Potential	10.0%	1.0 to 100	Percent as $CaCO_3$	

NOTES:

Table S.2 Substrate Calculations in Hydrogen Equivalents

Site Name: PRB Demonstration Test - Site B

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NOTE: Open cells are user input.

1. Treatment Zone Physical Dimensions

	Values	Range	Units
Width (Perpendicular to predominant groundwater flow direction)	200	1-10,000	feet
Length (Parallel to predominant groundwater flow)	10	1-1,000	feet
Saturated Thickness	40	1-100	feet
Treatment Zone Cross Sectional Area	8000	--	ft^2
Treatment Zone Volume	80,000	--	ft^3
Treatment Zone Effective Pore Volume (total volume x effective porosity)	149,640	--	gallons
Design Period of Performance	3.0	.5 to 5	year

2. Treatment Zone Hydrogeologic Properties

Total Porosity	0.25	.05-50	
Effective Porosity	0.25	.05-50	
Average Aquifer Hydraulic Conductivity	300	.01-1000	ft/day
Average Hydraulic Gradient	0.002	0.1-0.0001	ft/ft
Average Groundwater Seepage Velocity through the Treatment Zone	2.40	--	ft/day
Average Groundwater Seepage Velocity through the Treatment Zone	876.0	--	ft/yr
Average Groundwater Flux through the Treatment Zon 0	13,108,464	--	gallons/year
Soil Bulk Density	1.7	1.4-2.0	gm/cm^3
Soil Fraction Organic Carbon (foc)	0.0002	0.0001-0.1	

3. Initial Treatment Cell Electron-Acceptor Demand (one total pore volume)

A. Aqueous-Phase Native Electron Acceptors	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Oxygen	3.0	3.75	7.94	0.47	4
Nitrate (denitrification)	15.0	18.73	12.30	1.52	5
Sulfate	10	12.49	11.91	1.05	8
Carbon Dioxide (estimated as the amount of methane produced)	10.0	12.49	1.99	6.27	8
Soluble Competing Electron Acceptor Demand (lb.)				**9.32**	

B. Solid-Phase Native Electron Acceptors (Based on manganese and iron produced)	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Manganese (IV) (estimated as the amount of Mn (II) produced)	1.4	461.16	27.25	16.92	2
Iron (III) (estimated as the amount of Fe (II) produced)	20.0	6588.02	55.41	118.90	1
Solid-Phase Competing Electron Acceptor Demand (lb.)				**135.82**	

C. Soluble Contaminant Electron Acceptors	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Tetrachloroethene (PCE)	0.000	0.00	20.57	0.00	8
Trichloroethene (TCE)	0.000	0.00	21.73	0.00	6
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	0.000	0.00	24.05	0.00	4
Vinyl Chloride (VC)	0.000	0.00	31.00	0.00	2
Carbon Tetrachloride (CT)	0.000	0.00	19.08	0.00	8
Trichloromethane (or chloroform) (CF)	0.000	0.00	19.74	0.00	6
Dichloromethane (or methylene chloride) (MC)	0.000	0.00	21.06	0.00	4
Chloromethane	0.000	0.00	25.04	0.00	2
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	0.00	20.82	0.00	8
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	0.00	22.06	0.00	6
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	0.00	24.55	0.00	4
Chloroethane	0.000	0.00	32.00	0.00	2
Perchlorate	0.000	0.00	12.33	0.00	6
Total Soluble Contaminant Electron Acceptor Demand (lb.)				**0.00**	

D. Sorbed Contaminant Electron Acceptors (Soil Concentration = Koc x foc x Cgw)	Koc (mL/g)	Soil Conc. (mg/kg)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Tetrachloroethene (PCE)	263	0.00	0.00	20.57	0.00	8
Trichloroethene (TCE)	107	0.00	0.00	21.73	0.00	6
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	45	0.00	0.00	24.05	0.00	4
Vinyl Chloride (VC)	3.0	0.00	0.00	31.00	0.00	2
Carbon Tetrachloride (CT)	224	0.00	0.00	19.08	0.00	8
Trichloromethane (or chloroform) (CF)	63	0.00	0.00	19.74	0.00	6
Dichloromethane (or methylene chloride) (MC)	28	0.00	0.00	21.06	0.00	4
Chloromethane	25	0.00	0.00	25.04	0.00	2
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	117	0.00	0.00	20.82	0.00	8
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	105	0.00	0.00	22.06	0.00	6
Dichloroethane (1,1-DCA and 1,2-DCA)	30	0.00	0.00	24.55	0.00	4
Chloroethane	3	0.00	0.00	32.00	0.00	2
Perchlorate	0.0	0.00	0.00	12.33	0.00	6
Total Sorbed Contaminant Electron Acceptor Demand (lb.)					**0.00**	

(continued)

Table S.2 Substrate Calculations in Hydrogen Equivalents

4. Treatment Cell Electron-Acceptor Flux (per year)

A. Soluble Native Electron Acceptors	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Oxygen	3.0	328.15	7.94	41.33	4
Nitrate (denitrification)	15.0	1640.76	10.25	160.07	5
Sulfate	10	1093.84	11.91	91.84	8
Carbon Dioxide (estimated as the amount of Methane produced)	10	1093.84	1.99	549.67	8
Total Competing Electron Acceptor Demand Flux (lb/yr)				**842.9**	

B. Soluble Contaminant Electron Acceptors	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Tetrachloroethene (PCE)	0.000	0.00	20.57	0.00	8
Trichloroethene (TCE)	0.000	0.00	21.73	0.00	6
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	0.000	0.00	24.05	0.00	4
Vinyl Chloride (VC)	0.000	0.00	31.00	0.00	2
Carbon Tetrachloride (CT)	0.000	0.00	19.08	0.00	8
Trichloromethane (or chloroform) (CF)	0.000	0.00	19.74	0.00	6
Dichloromethane (or methylene chloride) (MC)	0.000	0.00	21.06	0.00	4
Chloromethane	0.000	0.00	25.04	0.00	2
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	0.00	20.82	0.00	8
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	0.00	22.06	0.00	6
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	0.00	24.55	0.00	4
Chloroethane	0.000	0.00	32.00	0.00	2
Perchlorate	0.000	0.00	12.33	0.00	6
Total Soluble Contaminant Electron Acceptor Demand Flux (lb/yr)				**0.00**	

Initial Hydrogen Requirement First Year (lb)	**988.1**
Total Life-Cycle Hydrogen Requirement (lb)	**2,673.9**

5. Design Factors

Microbial Efficiency Uncertainty Factor	2X - 4X
Methane and Solid-Phase Electron Acceptor Uncertainty	2X - 4X
Remedial Design Factor (e.g., Substrate Leaving Reaction Zone)	1X - 3X
Design Factor	**2.0**
Total Life-Cycle Hydrogen Requirement with Design Factor (lb)	**5,347.8**

6. Acronyns and Abbreviations

°C =degrees celsius
µs/cm = microsiemens per centimeter
cm/day = centimeters per day
cm/sec = centimeters per second
ft^2 = square feet
ft/day = feet per day
ft/ft = foot per foot
ft/yr = feet per year
gm/cm^3 = grams per cubic centimeter
kg of CaCO3 per mg = kilograms of calcium carbonate per milligram
lb = pounds
meq/100 g = milliequivalents per 100 grams
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
m/m = meters per meters
mV = millivolts
m/yr = meters per year
su = standard pH units
wt/wt H2 = concetration molecular hydrogen, weight per weight

Table S.3

Hydrogen Produced by Fermentation Reactions of Common Substrates

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Substrate	Molecular Formula	Substrate Molecular Weight (gm/mole)	Moles of Hydrogen Produced per Mole of Substrate	Ratio of Hydrogen Produced to Substrate (gm/gm)	Range of Moles H_2/Mole Substrate
Lactic Acid	$C_3H_6O_3$	90.1	2	0.0448	**2 to 3**
Molasses (assuming 100% sucrose)	$C_{12}H_{22}O_{11}$	342	8	0.0471	**8 to 11**
High Fructose Corn Syrup (assuming 50% fructose and 50% glucose)	$C_6H_{12}O_6$	180	4	0.0448	**4 to 6**
Ethanol	C_2H_6O	46.1	2	0.0875	**2 to 6**
Whey (assuming 100% lactose)	$C_{12}H_{22}O_{11}$	342	11	0.0648	**11**
HRC® (assumes 40% lactic acid and 40% glycerol by weight)	$C_{39}H_{56}O_{39}$	956	28	0.0590	**28**
Linoleic Acid (Soybean Oil, Corn Oil, Cotton Oil)	$C_{18}H_{32}O_2$	281	16	0.1150	**16**

Table S.4

Estimated Substrate Requirements for Hydrogen Demand in Table S.3

Design Life (years): 3

Substrate	Design Factor	Pure Substrate Mass Required to Fulfill Hydrogen Demand (pounds)	Substrate Product Required to Fulfill Hydrogen Demand (pounds)	Substrate Mass Required to Fulfill Hydrogen Demand (milligrams)	Effective Substrate Concentration (mg/L)
Lactic Acid	2.0	119,476	119,476	5.42E+10	363
Sodium Lactate Product (60 percent solution)	2.0	119,476	247,875	5.42E+10	363
Molasses (assuming 6 0	2.0	113,501	189,168	5.15E+10	345
HFCS (assuming 40% fructose and 40% glucose by weight)	2.0	119,502	149,378	5.42E+10	363
Ethanol Product (assuming 80% ethanol by weight)	2.0	61,104	76,380	2.77E+10	185
Whey (assuming 100% lactose)	2.0	82,474	117,819	3.74E+10	250
HRC® (assumes 40% lactic acid and 40% glycerol by weight)	2.0	90,569	90,569	4.11E+10	220
Linoleic Acid (Soybean Oil, Corn Oil, Cotton Oil)	2.0	46,504	46,504	2.11E+10	141
Commercial Vegetable Oil Emulsion Product (60% oil by weight)	2.0	46,504	77,507	2.11E+10	141

NOTES: Sodium Lactate Product

1. Assumes sodium lactate product is 60 percent sodium lactate by weight.
2. Molecular weight of sodium lactate (CH_3-CHOH-COONa) = 112.06.
3. Molecular weight of lactic Acid ($C_6H_6O_3$) = 90.08 .
4. Therefore, sodium lactate product yields 48.4 (0.60 x (90.08/112.06)) percent by weight lactic acid.
5. Weight of sodium lactate product = 11.0 pounds per gallon.
6. Pounds per gallon of lactic acid in product = 1.323 x 8.33 lb/gal H2O x 0.60 x (90.08/112.06) = 5.31 lb/gal.

NOTES: Standard HRC Product

1. Assumes HRC product is 40 percent lactic acid and 40 percent glycerol by weight.
2. HRC® weighs approximately 9.18 pounds per gallon.

NOTES: Vegetable Oil Emulsion Product

1. Assumes emulsion product is 60 percent soybean oil by weight.
2. Soybean oil is 7.8 pounds per gallon.
3. Assumes specific gravity of emulsion product is 0.96.

Table S.5 Output for Substrate Requirements in Hydrogen Equivalents

Site Name: PRB Demonstration Test - Site B

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1. Treatment Zone Physical Dimensions

	Values	Units	Values	Units
Width (perpendicular to groundwater flow)	200	feet	61	meters
Length (parallel to groundwater flow)	10	feet	3.0	meters
Saturated Thickness	40	feet	12.2	meters
Design Period of Performance	3	years	3	years

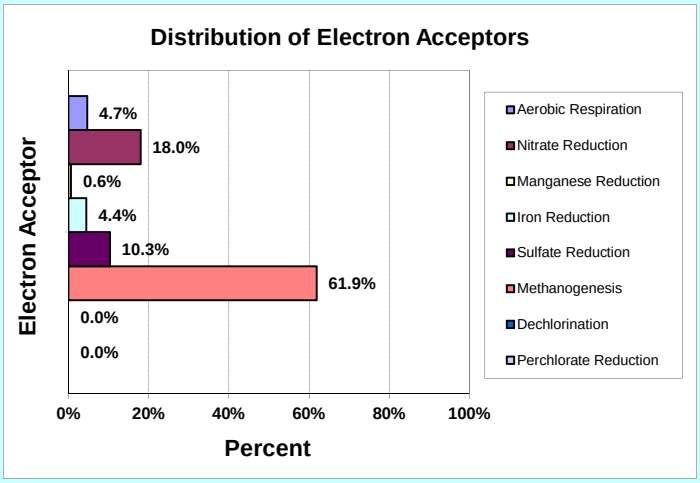
2. Treatment Zone Hydrogeologic Properties

	Values	Units	Values	Units
Total Porosity	0.25	percent	0.25	percent
Effective Porosity	0.25	percent	0.25	percent
Average Aquifer Hydraulic Conductivity	300	ft/day	1.1E-01	cm/sec
Average Hydraulic Gradient	0.002	ft/ft	0.002	m/m
Average Groundwater Seepage Velocity	2.40	ft/day	7.3E+01	cm/day
Average Groundwater Seepage Velocity	876	ft/yr	267.0	m/yr
Effective Treatment Zone Pore Volume	149,640	gallons	566,433	liters
Groundwater Flux (per year)	13,108,464	gallons/year	49,619,547	liters/year
Total Groundwater Volume Treated (over entire design period)	39,475,032	gallons total	149,425,075	liters total

3. Distribution of Electron Acceptor Demand

	Percent of Total	Hydrogen Demand (lb)
Aerobic Respiration	4.7%	124.459
Nitrate Reduction	18.0%	481.746
Sulfate Reduction	10.3%	276.575
Manganese Reduction	0.6%	16.923
Iron Reduction	4.4%	118.896
Methanogenesis	61.9%	1655.281
Dechlorination	0.0%	0.000
Perchlorate Reduction	0.0%	0.000
Totals:	**100.00%**	**2673.88**

Hydrogen demand in pounds/gallon:	6.77E-05
Hydrogen demand in grams per liter:	8.12E-03



4. Substrate Equivalents: Design Factor = 2.0

Product	Quantity (lb)	Quantity (gallons)	Effective Concentration (mg/L)	Effective concentration is for total volume of groundwater treated.
1. Sodium Lactate Product	247,875	22,534	363	as lactic acid
2. Molasses Product	189,168	15,764	345	as sucrose
3. Fructose Product	149,378	13,337	363	as fructose
4. Ethanol Product	76,380	11,070	185	as ethanol
5. Sweet Dry Whey (lactose)	117,819	sold by pound	250	as lactose
6. HRC®	90,569	sold by pound	220	as 40% lactic acid/40% glycerol
7. Linoleic Acid (Soybean Oil)	46,504	5,962	141	as soybean oil
8. Emulsified Vegetable Oil	77,507	9,937	141	as soybean oil

Notes:

1. Quantity assumes product is 60% sodium lactate by weight.
2. Quantity assumes product is 60% sucrose by weight and weighs 12 pounds per gallon.
3. Quantity assumes product is 80% fructose by weight and weighs 11.2 pounds per gallon.
4. Quantity assumes product is 80% ethanol by weight and weighs 6.9 pounds per gallon.
5. Quantity assumes product is 70% lactose by weight.
6. Quantity assumes HRC® is 40% lactic acid and 40% glycerol by weight.
7. Quantity of neat soybean oil, corn oil, or canola oil.
8. Quantity assumes commercial product is 60% soybean oil by weight.

Appendix G

Nitrogen Mass Flux and Nitrogen Removal Cost Calculations

Town of Orleans, Massachusetts
Water Quality and Wastewater Planning
Non-Traditional Technologies - Permeable Reactive Barriers
Calculations of Nitrogen Flux Removal and Associated Costs

Calculation Summary: This calculation estimates the nitrogen flux (mass per time) passing through a permeable reactive barrier (PRB). Groundwater conditions can vary spatially and design of full-scale PRBs will be determined based on additional data collection associated with the Demonstration Tests. Therefore, a sensitivity analysis is provided in this calculation to quantify range of values and anticipated average conditions.

Parameter	Units	Low Range Flux	High Range Flux	Average Flux
Groundwater Seepage Velocity	ft/d	1.00	5.00	1.50
Porosity	unitless	0.25	0.35	0.30
Darcy Velocity	ft/d	0.25	1.75	0.45
Vertical Treatment	feet	35.00	45.00	40.00
Groundwater Flux	ft3 / d-ft length	8.75	78.75	18.00
PRB Length	feet	3,000	4,000	3,500
PRB Groundwater Flux	ft3 / day	26,250	315,000	63,000
PRB Groundwater Flux	L/day	743,316	8,919,792	1,783,958
Average Nitrate Concentration	mg/L	2.00	10.00	5.00
Nitrate Flux	kg /yr-ft length	0.18	8.14	0.93
PRB Nitrate Flux	kg/year	543	32,557	3,256
PRB Nitrate Flux (5 years)	kg	2,713	162,786	16,279
PRB Nitrate Flux (20 years)	kg	10,852	651,145	65,114

Town of Orleans, Massachusetts
Water Quality and Wastewater Planning
Non-Traditional Technologies - Permeable Reactive Barriers
Calculations of Nitrogen Flux Removal and Associated Costs

Calculation Summary: This calculation estimates the full scale PRB costs using average nitrate flux for three different PRB life lengths (3, 5, and 7 years). The calculation also includes a 20-year cost estimate for each scenario.

Cost Sensitivity Analysis
Using Average Nitrate Flux and Average Costs

Parameter	Units	3-Year PRB Rejuvenation	5-Year PRB Rejuvenation	7-Year PRB Rejuvenation
PRB Life Time/Rejuvenation Frequency	years	3	5	7
Full Scale PRB Construction	$/linear foot	$840	$840	$840
Full Scale PRB Annual Monitoring	$/linear foot-year	$124	$124	$124
Full Scale PRB Annual Replacement Costs	$/linear foot-year	$7	$7	$7
Full Scale PRB Rejuvenation	$/linear foot	$670	$670	$670
Full Scale PRB Length	feet	3500	3500	3500
Full Scale PRB Initial Construction	$	$2,940,000	$2,940,000	$2,940,000
Full Scale PRB Rejuvenation Construction	$	$2,345,000	$2,345,000	$2,345,000
Full Scale PRB Monitoring Cost (20 years)	$	$8,680,000	$8,680,000	$8,680,000
Full Scale PRB Replacement Cost (20 years)	$	$490,000	$490,000	$490,000
Rejuvenation Events for 20 years	#	6	3	2
Full Scale PRB Cost for Rejuventation (20 years)	$	$ 14,070,000	$ 7,035,000	$ 4,690,000
Full Scale PRB Total Cost (20 years)	$	$ 26,180,000	$ 19,145,000	$ 16,800,000
Average Annual PRB Nitrate Flux (3,500 LF barrier)	kg/yr	3256	3256	3256
PRB Nitrate Flux (20 years)	kg	65114	65114	65114
Full Scale PRB Nitrogen Removal Cost (20 year operations)	$/kg	$402	$294	$258

Appendix H

Analytical Laboratory Data and Reports

Analytical Laboratory Reports for AECOM 2016 Sampling

CERTIFICATE OF ANALYSIS

Mark Owens
AECOM Environment - ENSR
9 Jonathon Bourne Dr.
Pocasset, MA 02559

RE: Orleans MA (60476644 Task 03.3)
ESS Laboratory Work Order Number: 1602108

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By mpagliarini at 12:09 pm, Feb 16, 2016

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with NELAC Standards, A2LA and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602108

SAMPLE RECEIPT

The following samples were received on February 04, 2016 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
1602108-01	MW-A1-C	Ground Water	200.7, 350.1, 353.2, 4500N, 9038, 9250
1602108-02	MW-G1-B	Ground Water	200.7, 350.1, 353.2, 4500N, 9038, 9250
1602108-03	MW-A1-A	Ground Water	200.7, 350.1, 353.2, 4500N, 9038, 9250
1602108-04	MW-A1-B	Ground Water	200.7, 350.1, 353.2, 4500N, 5310B, 9038, 9250
1602108-05	MW-A1-B-2	Ground Water	200.7, 350.1, 353.2, 4500N, 5310B, 9038, 9250
1602108-06	MW-G1-A	Ground Water	200.7, 350.1, 353.2, 4500N, 5310B, 9038, 9250

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602108

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602108

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015D - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH / VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035 - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A1-C
Date Sampled: 02/03/16 15:40
Percent Solids: N/A

ESS Laboratory Work Order: 1602108
ESS Laboratory Sample ID: 1602108-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 3005A
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**5.6** (0.05)		200.7		1	KJK	02/10/16 4:31	50	25	CB60414
Manganese	**0.5** (0.01)		200.7		1	KJK	02/10/16 4:31	50	25	CB60414

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A1-C
Date Sampled: 02/03/16 15:40
Percent Solids: N/A

ESS Laboratory Work Order: 1602108
ESS Laboratory Sample ID: 1602108-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	**0.22** (0.10)		350.1		1	JLK	02/10/16 16:48	mg/L	CB60901
Chloride	**162** (15.0)		9250		5	EEM	02/08/16 15:06	mg/L	CB60815
Nitrate as N	**0.031** (0.030)		353.2		1	JLK	02/05/16 9:30	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	02/05/16 8:17	mg/L	CB60501
Sulfate	**22.0** (5.0)		9038		1	EEM	02/05/16 15:55	mg/L	CB60530
Total Nitrogen	**0.60** (0.22)		4500N		1	JLK	02/06/16 10:02	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-G1-B
Date Sampled: 02/03/16 13:35
Percent Solids: N/A

ESS Laboratory Work Order: 1602108
ESS Laboratory Sample ID: 1602108-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 3005A
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.1** (0.05)		200.7		1	KJK	02/10/16 4:48	50	25	CB60414
Manganese	**0.4** (0.01)		200.7		1	KJK	02/10/16 4:48	50	25	CB60414

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-G1-B
Date Sampled: 02/03/16 13:35
Percent Solids: N/A

ESS Laboratory Work Order: 1602108
ESS Laboratory Sample ID: 1602108-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	ND (0.10)		350.1		1	JLK	02/10/16 16:50	mg/L	CB60901
Chloride	**283** (30.0)		9250		10	EEM	02/08/16 15:08	mg/L	CB60815
Nitrate as N	**0.444** (0.030)		353.2		1	JLK	02/05/16 9:34	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	02/05/16 8:20	mg/L	CB60501
Sulfate	**10.2** (5.0)		9038		1	EEM	02/05/16 15:55	mg/L	CB60530
Total Nitrogen	**0.44** (0.22)		4500N		1	JLK	02/06/16 10:03	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A1-A
Date Sampled: 02/03/16 17:05
Percent Solids: N/A

ESS Laboratory Work Order: 1602108
ESS Laboratory Sample ID: 1602108-03
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 3005A
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.05)		200.7		1	KJK	02/10/16 4:53	50	25	CB60414
Manganese	**0.2** (0.01)		200.7		1	KJK	02/10/16 4:53	50	25	CB60414

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A1-A
Date Sampled: 02/03/16 17:05
Percent Solids: N/A

ESS Laboratory Work Order: 1602108
ESS Laboratory Sample ID: 1602108-03
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	**0.10** (0.10)		350.1		1	JLK	02/10/16 16:51	mg/L	CB60901
Chloride	**42.6** (3.0)		9250		1	EEM	02/08/16 14:59	mg/L	CB60815
Nitrate as N	**5.26** (0.210)		353.2		10	JLK	02/05/16 10:15	mg/L	[CALC]
Nitrite as N	**0.050** (0.010)		353.2		1	JLK	02/05/16 8:21	mg/L	CB60501
Sulfate	**6.2** (5.0)		9038		1	EEM	02/05/16 15:55	mg/L	CB60530
Total Nitrogen	**5.31** (0.40)		4500N		10	JLK	02/06/16 10:03	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A1-B
Date Sampled: 02/03/16 16:20
Percent Solids: N/A

ESS Laboratory Work Order: 1602108
ESS Laboratory Sample ID: 1602108-04
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 3005A
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.05)		200.7		1	KJK	02/10/16 4:57	50	25	CB60414
Manganese	**0.4** (0.01)		200.7		1	KJK	02/10/16 4:57	50	25	CB60414

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A1-B
Date Sampled: 02/03/16 16:20
Percent Solids: N/A

ESS Laboratory Work Order: 1602108
ESS Laboratory Sample ID: 1602108-04
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 3005A
All methods used are in accordance with 40 CFR 136.

Total Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Boron	ND (0.050)		200.7		1	KJK	02/10/16 15:17	50	25	CB60512

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A1-B
Date Sampled: 02/03/16 16:20
Percent Solids: N/A

ESS Laboratory Work Order: 1602108
ESS Laboratory Sample ID: 1602108-04
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	ND (0.10)		350.1		1	JLK	02/10/16 16:52	mg/L	CB60901
Chloride	**38.7** (3.0)		9250		1	EEM	02/08/16 15:00	mg/L	CB60815
Dissolved Organic Carbon (Average)	**0.6** (0.5)		5310B		1	NAR	02/11/16 20:17	mg/L	[CALC]
Nitrate as N	**3.14** (0.110)		353.2		5	JLK	02/05/16 10:16	mg/L	[CALC]
Nitrite as N	**0.020** (0.010)		353.2		1	JLK	02/05/16 8:22	mg/L	CB60501
Sulfate	**6.5** (5.0)		9038		1	EEM	02/05/16 15:55	mg/L	CB60530
Total Nitrogen	**3.41** (0.30)		4500N		5	JLK	02/06/16 10:04	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A1-B-2
Date Sampled: 02/03/16 16:25
Percent Solids: N/A

ESS Laboratory Work Order: 1602108
ESS Laboratory Sample ID: 1602108-05
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 3005A
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.1** (0.05)		200.7		1	KJK	02/10/16 5:01	50	25	CB60414
Manganese	**0.5** (0.01)		200.7		1	KJK	02/10/16 5:01	50	25	CB60414

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A1-B-2
Date Sampled: 02/03/16 16:25
Percent Solids: N/A

ESS Laboratory Work Order: 1602108
ESS Laboratory Sample ID: 1602108-05
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 3005A
All methods used are in accordance with 40 CFR 136.

Total Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Boron	ND (0.050)		200.7		1	KJK	02/10/16 15:21	50	25	CB60512

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A1-B-2
Date Sampled: 02/03/16 16:25
Percent Solids: N/A

ESS Laboratory Work Order: 1602108
ESS Laboratory Sample ID: 1602108-05
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	ND (0.10)		350.1		1	JLK	02/10/16 16:54	mg/L	CB60901
Chloride	**38.3** (3.0)		9250		1	EEM	02/08/16 15:00	mg/L	CB60815
Dissolved Organic Carbon (Average)	ND (0.5)		5310B		1	NAR	02/11/16 21:29	mg/L	[CALC]
Nitrate as N	**3.16** (0.110)		353.2		5	JLK	02/05/16 10:17	mg/L	[CALC]
Nitrite as N	**0.018** (0.010)		353.2		1	JLK	02/05/16 8:23	mg/L	CB60501
Sulfate	**6.6** (5.0)		9038		1	EEM	02/05/16 15:55	mg/L	CB60530
Total Nitrogen	**3.18** (0.30)		4500N		5	JLK	02/06/16 10:05	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-G1-A
Date Sampled: 02/03/16 12:32
Percent Solids: N/A

ESS Laboratory Work Order: 1602108
ESS Laboratory Sample ID: 1602108-06
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 3005A
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.06** (0.05)		200.7		1	KJK	02/10/16 5:06	50	25	CB60414
Manganese	**0.08** (0.01)		200.7		1	KJK	02/10/16 5:06	50	25	CB60414

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-G1-A
Date Sampled: 02/03/16 12:32
Percent Solids: N/A

ESS Laboratory Work Order: 1602108
ESS Laboratory Sample ID: 1602108-06
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 3005A
All methods used are in accordance with 40 CFR 136.

Total Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Boron	ND (0.050)		200.7		1	KJK	02/10/16 15:26	50	25	CB60512

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-G1-A
Date Sampled: 02/03/16 12:32
Percent Solids: N/A

ESS Laboratory Work Order: 1602108
ESS Laboratory Sample ID: 1602108-06
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	ND (0.10)		350.1		1	JLK	02/10/16 16:55	mg/L	CB60901
Chloride	**233** (30.0)		9250		10	EEM	02/08/16 15:09	mg/L	CB60815
Dissolved Organic Carbon (Average)	ND (0.5)		5310B		1	NAR	02/11/16 21:42	mg/L	[CALC]
Nitrate as N	**0.885** (0.030)		353.2		1	JLK	02/05/16 9:38	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	02/05/16 8:26	mg/L	CB60501
Sulfate	**13.3** (5.0)		9038		1	EEM	02/05/16 15:55	mg/L	CB60530
Total Nitrogen	**1.13** (0.22)		4500N		1	JLK	02/06/16 10:05	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602108

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch CB60414 - 3005A										
Blank										
Iron	ND	0.05	mg/L							
Manganese	ND	0.01	mg/L							
LCS										
Iron	1.2	0.05	mg/L	1.250		99	80-120			
Manganese	0.2	0.01	mg/L	0.2500		99	80-120			
LCS Dup										
Iron	1.2	0.05	mg/L	1.250		100	80-120	0.9	20	
Manganese	0.2	0.01	mg/L	0.2500		99	80-120	0.4	20	
Total Metals										
Batch CB60512 - 3005A										
Blank										
Boron	ND	0.050	mg/L							
LCS										
Boron	0.239	0.050	mg/L	0.2500		95	85-115			
LCS Dup										
Boron	0.255	0.050	mg/L	0.2500		102	85-115	7	20	
Classical Chemistry										
Batch CB60501 - [CALC]										
Blank										
Nitrate as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrate as N	ND		mg/L							
Nitrite as N	0.243		mg/L	0.2497		97	90-110			
Nitrite as N	0.243		mg/L	0.2497		97	90-110			
Batch CB60502 - [CALC]										
Blank										
Nitrate as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
Total Nitrogen	ND	0.02	mg/L							
LCS										
Nitrate as N	0.498		mg/L							
Nitrate/Nitrite as N	0.498		mg/L	0.5000		100	90-110			
Nitrate/Nitrite as N	0.498		mg/L	0.5000		100	90-110			
Total Nitrogen	0.498		mg/L							
Batch CB60530 - General Preparation										

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602108

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Classical Chemistry										
Batch CB60530 - General Preparation										
Blank										
Sulfate	ND	5.0	mg/L							
LCS										
Sulfate	9.5		mg/L	9.988		95	85-115			
Batch CB60535 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
Total Nitrogen	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	15.5	2.00	mg/L	17.60		88	80-120			
Total Nitrogen	15.5	2.00	mg/L							
Batch CB60815 - General Preparation										
Blank										
Chloride	ND	3.0	mg/L							
LCS										
Chloride	28.3		mg/L	30.00		94	90-110			
Batch CB60901 - General Preparation										
Blank										
Ammonia as N	ND	0.10	mg/L							
LCS										
Ammonia as N	0.11	0.10	mg/L	0.09994		115	80-120			
LCS										
Ammonia as N	1.06	0.10	mg/L	0.9994		106	80-120			
Batch CB61138 - General No Prep										
Blank										
Dissolved Organic Carbon (1)	ND	0.5	mg/L							
Dissolved Organic Carbon (2)	ND	0.5	mg/L							
Dissolved Organic Carbon (Average)	ND	0.5	mg/L							
LCS										
Dissolved Organic Carbon (1)	4.79	0.5	mg/L	5.000		96	80-120			
Dissolved Organic Carbon (2)	4.88	0.5	mg/L	5.000		98	80-120			
Dissolved Organic Carbon (Average)	4.80	0.5	mg/L							
LCS Dup										
Dissolved Organic Carbon (1)	4.81	0.5	mg/L	5.000		96	80-120	0.4	200	
Dissolved Organic Carbon (2)	4.90	0.5	mg/L	5.000		98	80-120	0.4	200	
Dissolved Organic Carbon (Average)	4.90	0.5	mg/L							

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602108

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602108

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/water/dwp-services/labcert/documents/AllLabs.xls

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

United States Department of Agriculture Soil Permit: P330-12-00139

Pennsylvania: 68-01752
http://www.depweb.state.pa.us/portal/server.pt/community/labs/13780/laboratory_accreditation_program/590095

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB/MM

Shipped/Delivered Via: ESS Courier

ESS Project ID: 1602108
Date Received: 2/4/2016
Project Due Date: 2/11/2016
Days for Project: 5 Day

1. Air bill manifest present? Yes
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 5.6 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** (Yes) / No / NA
10. Were any analyses received outside of hold time? Yes / (No)

11. Any Subcontracting needed? Yes / (No)
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / (No)
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA

13. Are the samples properly preserved? (Yes) / No
    a. If metals preserved in SR: Date: Time: By:
    b. Low Level VOAs brought to freezer: Date: Time: By:

Sample Receiving Notes:

Was there a need to contact the client? Yes / No
Who was contacted? Date: Time: By:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
01	6390	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
01	6396	Yes	NA	Yes	500 mL Poly - Unpres	NP	
01	6402	Yes	NA	Yes	250 mL Poly - Unpres	NP	
02	6389	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
02	6395	Yes	NA	Yes	500 mL Poly - Unpres	NP	
02	6401	Yes	NA	Yes	250 mL Poly - Unpres	NP	
03	6388	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
03	6394	Yes	NA	Yes	500 mL Poly - Unpres	NP	
03	6400	Yes	NA	Yes	250 mL Poly - Unpres	NP	
04	6387	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
04	6393	Yes	NA	Yes	500 mL Poly - Unpres	NP	
04	6399	Yes	NA	Yes	250 mL Poly - Unpres	NP	
04	6405	Yes	NA	Yes	250 mL Poly - HNO3	HNO3	
04	6408	Yes	NA	Yes	250 mL Amber - Unpres	NP	
04	6413	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4	
04	6414	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4	
05	6386	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
05	6392	Yes	NA	Yes	500 mL Poly - Unpres	NP	
05	6398	Yes	NA	Yes	250 mL Poly - Unpres	NP	
05	6404	Yes	NA	Yes	250 mL Poly - HNO3	HNO3	
05	6407	Yes	NA	Yes	250 mL Amber - Unpres	NP	
05	6411	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4	
05	6412	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4	

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB/MM

ESS Project ID: 1602108

Date Received: 2/4/2016

06	6385	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
06	6391	Yes	NA	Yes	500 mL Poly - Unpres	NP
06	6397	Yes	NA	Yes	250 mL Poly - Unpres	NP
06	6403	Yes	NA	Yes	250 mL Poly - HNO3	HNO3
06	6406	Yes	NA	Yes	250 mL Amber - Unpres	NP
06	6409	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4
06	6410	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4

2nd Review

Are barcode labels on correct containers? (Yes) / No

Completed By: _____ Date & Time: 2/4/16 0933

Reviewed By: Tarisa Badger Date & Time: 2/4/16 1016

1602108

Shuttle/Cooler ID#:

CHAIN OF CUSTODY

Geochemical Testing

Form F-5002, 07.14

Geochemical Testing • 2005 North Center Avenue • Somerset PA 15501 • (814) 443-1671 • Fax (814) 445-6729

Billing Client: AECOM	**Contact (Company):** MARK OWEN		**Phone:** (508) 833-6950
Address: 9 Jonathan Bourne DR	e-mail: MARK.OWEN@AECOM.COM		Fax: ( )
City: Pocasset **State:** MA **Zip:**	**Sampled by:** KMC + BKM		**Preservatives by** __Sampler__GT
WO#:	Project: ORLEANS	**DEP Reporting**	PO/Quote#:

Sample Matrix:	**GW** Ground Water	**SW** Surface Water	**PW** Potable Water	**WW** Wastewater	**SO** Soil	**SL** Sludge	**nHZ** Not Hazardous / **HZ** Hazardous	**PCBs**
Sample Type:	**G** Grab	**C** Composite	**D** Distribution/DW	**R** Raw/DW	**S** Special/DW	**O** Other	Containers Supplied by: ☐ Client ☐ GT Lab	

	Sample Location/ Description	Lab Number	Sample Matrix	Date	Time (Military)	Sample Type	**Analyses Requested	Remarks/ Preservatives, etc	Number of Containers
	***NOTE: IF multiple analytes from one bottle, OR if multiple bottles for one analyte, THEN list separately on one line UNLESS LISTED ON ATTACHED FIELD LOG*								
1	MW-A1-C		GW	02/03/16	15:40	G	Amm+TN, Dis Metals, NO_2, NO_3 Chloride, Sulfate	Field Filtered: Y (N)	3
2	MW-G1-B		GW	02/03/16	13:35	G	Amm+TN, Dis Metals, NO_2, NO_3, Chloride, Sulfate	Field Filtered: Y (N)	3
3	MW-A1-A		GW	02/03/16	17:05	G	Amm+TN Dis Metals, NO_2 NO_3, Chloride, Sulfate	Field Filtered: Y (N)	3
4	MW-A1-B		GW	02/03/16	16:20	G	Amm+TN, Dis Metals, DOC NO_2 NO_3 Chloride, Sulfate, Boron	Field Filtered: Y (N)	5
5	MW-A1-B2		GW	02/03/16	16:25	G	Amm+TN, Dis Metals, DOC NO_2, NO_3 Chloride Sulfate, Boron	Field Filtered: Y (N) DUP	5
6	MW-B1-A		GW	02/03/16	12:32	G	Amm+TN Dis Metals, DOC NO_2 NO_3 Chloride, Sulfate, Boron	Field Filtered: Y (N)	5
								Field Filtered: Y / N	
					BKM 02/03/16			Field Filtered: Y / N	

Note Deficiencies Here:

Relinquished by (Company & Signature)	Date	Time (Military)	Received by (Company & Signature):	Date	Time (Military)
Briley Morrill / AECOM	02/04/16	0800		2/4/16	800
Briley Morrill				↓	↓
	2/4/16	0915	ESS	2/4/16	0922

SAMPLES MUST BE PRESERVED ON ICE.

Ice present on receipt: ✓ Yes or ___ No | Cooler Temp (°C) on receipt: 5.6°C KB 2/4/16

Sample Receiving (1st Review):_____ | Client Support (2nd Review):_____

CERTIFICATE OF ANALYSIS

Mark Owens
AECOM Environment - ENSR
9 Jonathon Bourne Dr.
Pocasset, MA 02559

RE: Orleans MA (6047664 Task 03.3)
ESS Laboratory Work Order Number: 1602147

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By mpagliarini at 4:54 pm, Feb 16, 2016

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with NELAC Standards, A2LA and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602147

SAMPLE RECEIPT

The following samples were received on February 04, 2016 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
1602147-01	MW-A3-B	Aqueous	200.7, 350.1, 353.2, 4500N, 5310B, 9038, 9250
1602147-02	MW-A3-A	Aqueous	200.7, 350.1, 353.2, 4500N, 9038, 9250
1602147-03	MW-A3-C	Aqueous	200.7, 350.1, 353.2, 4500N, 9038, 9250
1602147-04	MW-5	Aqueous	200.7, 350.1, 353.2, 4500N, 9038, 9250

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602147

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602147

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015D - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH / VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035 - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A3-B
Date Sampled: 02/04/16 12:55
Percent Solids: N/A

ESS Laboratory Work Order: 1602147
ESS Laboratory Sample ID: 1602147-01
Sample Matrix: Aqueous
Units: mg/L

Extraction Method: 3005A
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**12.2** (0.05)		200.7		1	KJK	02/10/16 16:09	50	25	CB60512
Manganese	**1.7** (0.01)		200.7		1	KJK	02/10/16 16:09	50	25	CB60512

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A3-B
Date Sampled: 02/04/16 12:55
Percent Solids: N/A

ESS Laboratory Work Order: 1602147
ESS Laboratory Sample ID: 1602147-01
Sample Matrix: Aqueous
Units: mg/L

Extraction Method: 3005A
All methods used are in accordance with 40 CFR 136.

Total Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Boron	ND (0.050)		200.7		1	KJK	02/11/16 17:35	50	25	CB61001

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A3-B
Date Sampled: 02/04/16 12:55
Percent Solids: N/A

ESS Laboratory Work Order: 1602147
ESS Laboratory Sample ID: 1602147-01
Sample Matrix: Aqueous

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	**0.58** (0.10)		350.1		1	JLK	02/10/16 16:56	mg/L	CB60901
Chloride	**361** (30.0)		9250		10	EEM	02/08/16 15:09	mg/L	CB60815
Dissolved Organic Carbon (Average)	ND (0.5)		5310B		1	NAR	02/11/16 22:41	mg/L	[CALC]
Nitrate as N	**1.76** (0.050)		353.2		2	JLK	02/05/16 10:20	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	02/05/16 8:30	mg/L	CB60501
Sulfate	**7.8** (5.0)		9038		1	EEM	02/05/16 15:55	mg/L	CB60530
Total Nitrogen	**2.52** (0.240)		4500N		2	EEM	02/10/16 11:42	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A3-A
Date Sampled: 02/04/16 14:30
Percent Solids: N/A

ESS Laboratory Work Order: 1602147
ESS Laboratory Sample ID: 1602147-02
Sample Matrix: Aqueous
Units: mg/L

Extraction Method: 3005A
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**12.9** (0.05)		200.7		1	KJK	02/10/16 16:13	50	25	CB60512
Manganese	**3.4** (0.01)		200.7		1	KJK	02/10/16 16:13	50	25	CB60512

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A3-A
Date Sampled: 02/04/16 14:30
Percent Solids: N/A

ESS Laboratory Work Order: 1602147
ESS Laboratory Sample ID: 1602147-02
Sample Matrix: Aqueous

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	**0.64** (0.10)		350.1		1	JLK	02/10/16 16:56	mg/L	CB60901
Chloride	**321** (30.0)		9250		10	EEM	02/08/16 15:11	mg/L	CB60815
Nitrate as N	**1.73** (0.050)		353.2		2	JLK	02/05/16 10:21	mg/L	[CALC]
Nitrite as N	**0.044** (0.010)		353.2		1	JLK	02/05/16 8:31	mg/L	CB60501
Sulfate	**10.7** (5.0)		9038		1	EEM	02/05/16 15:55	mg/L	CB60530
Total Nitrogen	**2.40** (0.240)		4500N		2	EEM	02/10/16 11:43	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A3-C
Date Sampled: 02/04/16 13:40
Percent Solids: N/A

ESS Laboratory Work Order: 1602147
ESS Laboratory Sample ID: 1602147-03
Sample Matrix: Aqueous
Units: mg/L

Extraction Method: 3005A
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.05)		200.7		1	KJK	02/10/16 16:17	50	25	CB60512
Manganese	**0.1** (0.01)		200.7		1	KJK	02/10/16 16:17	50	25	CB60512

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A3-C
Date Sampled: 02/04/16 13:40
Percent Solids: N/A

ESS Laboratory Work Order: 1602147
ESS Laboratory Sample ID: 1602147-03
Sample Matrix: Aqueous

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	ND (0.10)		350.1		1	JLK	02/10/16 16:57	mg/L	CB60901
Chloride	**597** (30.0)		9250		10	EEM	02/08/16 15:12	mg/L	CB60815
Nitrate as N	**1.61** (0.110)		353.2		5	JLK	02/05/16 10:22	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	02/05/16 8:32	mg/L	CB60501
Sulfate	**17.1** (5.0)		9038		1	EEM	02/05/16 15:55	mg/L	CB60530
Total Nitrogen	**1.83** (0.300)		4500N		5	EEM	02/10/16 11:44	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-5
Date Sampled: 02/04/16 15:40
Percent Solids: N/A

ESS Laboratory Work Order: 1602147
ESS Laboratory Sample ID: 1602147-04
Sample Matrix: Aqueous
Units: mg/L

Extraction Method: 3005A
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.05)		200.7		1	KJK	02/10/16 16:22	50	25	CB60512
Manganese	**0.08** (0.01)		200.7		1	KJK	02/10/16 16:22	50	25	CB60512

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-5
Date Sampled: 02/04/16 15:40
Percent Solids: N/A

ESS Laboratory Work Order: 1602147
ESS Laboratory Sample ID: 1602147-04
Sample Matrix: Aqueous

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	ND (0.10)		350.1		1	JLK	02/10/16 16:58	mg/L	CB60901
Chloride	**86.7** (3.0)		9250		1	EEM	02/08/16 15:05	mg/L	CB60815
Nitrate as N	**3.71** (0.110)		353.2		5	JLK	02/05/16 10:23	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	02/05/16 8:33	mg/L	CB60501
Sulfate	**9.2** (5.0)		9038		1	EEM	02/05/16 15:55	mg/L	CB60530
Total Nitrogen	**3.71** (0.300)		4500N		5	EEM	02/10/16 11:44	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602147

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch CB60512 - 3005A										
Blank										
Iron	ND	0.05	mg/L							
Manganese	ND	0.01	mg/L							
Blank										
Iron	ND	0.05	mg/L							
Manganese	ND	0.01	mg/L							
LCS										
Iron	1.2	0.05	mg/L	1.250		96	80-120			
Manganese	0.2	0.01	mg/L	0.2500		98	80-120			
LCS Dup										
Iron	1.3	0.05	mg/L	1.250		102	80-120	7	20	
Manganese	0.3	0.01	mg/L	0.2500		105	80-120	7	20	
Total Metals										
Batch CB61001 - 3005A										
Blank										
Boron	ND	0.050	mg/L							
LCS										
Boron	0.252	0.050	mg/L	0.2500		101	85-115			
LCS Dup										
Boron	0.255	0.050	mg/L	0.2500		102	85-115	1	20	
Classical Chemistry										
Batch CB60501 - [CALC]										
Blank										
Nitrate as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrate as N	ND		mg/L							
Nitrite as N	0.243		mg/L	0.2497		97	90-110			
Nitrite as N	0.243		mg/L	0.2497		97	90-110			
Batch CB60502 - [CALC]										
Blank										
Nitrate as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
Total Nitrogen	ND	0.020	mg/L							
LCS										
Nitrate as N	0.498		mg/L							
Nitrate/Nitrite as N	0.498		mg/L	0.5000		100	90-110			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602147

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Classical Chemistry										
Batch CB60502 - General Preparation										
Nitrate/Nitrite as N	0.498		mg/L	0.5000		100	90-110			
Total Nitrogen	0.498		mg/L							
Batch CB60530 - General Preparation										
Blank										
Sulfate	ND	5.0	mg/L							
LCS										
Sulfate	9.5		mg/L	9.988		95	85-115			
Batch CB60815 - General Preparation										
Blank										
Chloride	ND	3.0	mg/L							
LCS										
Chloride	28.3		mg/L	30.00		94	90-110			
Batch CB60901 - General Preparation										
Blank										
Ammonia as N	ND	0.10	mg/L							
LCS										
Ammonia as N	0.11	0.10	mg/L	0.09994		115	80-120			
LCS										
Ammonia as N	1.06	0.10	mg/L	0.9994		106	80-120			
Batch CB60914 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
Total Nitrogen	ND	0.200	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	19.5	2.00	mg/L	17.60		111	80-120			
Total Nitrogen	19.5	2.00	mg/L							
Batch CB61138 - General No Prep										
Blank										
Dissolved Organic Carbon (1)	ND	0.5	mg/L							
Dissolved Organic Carbon (2)	ND	0.5	mg/L							
Dissolved Organic Carbon (Average)	ND	0.5	mg/L							
LCS										
Dissolved Organic Carbon (1)	4.8	0.5	mg/L	5.000		96	80-120			
Dissolved Organic Carbon (2)	4.9	0.5	mg/L	5.000		98	80-120			
Dissolved Organic Carbon (Average)	4.80	0.5	mg/L							
LCS Dup										
Dissolved Organic Carbon (1)	4.8	0.5	mg/L	5.000		96	80-120	0.4	200	
Dissolved Organic Carbon (2)	4.9	0.5	mg/L	5.000		98	80-120	0.4	200	
Dissolved Organic Carbon (Average)	4.90	0.5	mg/L							

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602147

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602147

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/water/dwp-services/labcert/documents/AllLabs.xls

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

United States Department of Agriculture Soil Permit: P330-12-00139

Pennsylvania: 68-01752
http://www.depweb.state.pa.us/portal/server.pt/community/labs/13780/laboratory_accreditation_program/590095

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB/MM

Shipped/Delivered Via: ESS Courier

ESS Project ID: 1602147
Date Received: 2/4/2016
Project Due Date: 2/11/2016
Days for Project: 5 Day

1. Air bill manifest present? Yes
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 1.0 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** (Yes) No / NA
10. Were any analyses received outside of hold time? Yes / (No)

11. Any Subcontracting needed? Yes / (No)
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / (No)
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / (NA)

13. Are the samples properly preserved? (Yes) / No
    a. If metals preserved in SR: Date: Time: By:
    b. Low Level VOAs brought to freezer: Date: Time: By:

Sample Receiving Notes:

Was there a need to contact the client? Yes / No
Who was contacted? Date: Time: By:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
01	6816	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
01	6820	Yes	NA	Yes	500 mL Poly - Unpres	NP	
01	6824	Yes	NA	Yes	250 mL Poly - Unpres	NP	
01	6827	Yes	NA	Yes	250 mL Poly - HNO3	HNO3	
01	6828	Yes	NA	Yes	250 mL Amber - Unpres	NP	
02	6815	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
02	6819	Yes	NA	Yes	500 mL Poly - Unpres	NP	
02	6823	Yes	NA	Yes	250 mL Poly - Unpres	NP	
03	6814	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
03	6818	Yes	NA	Yes	500 mL Poly - Unpres	NP	
03	6822	Yes	NA	Yes	250 mL Poly - Unpres	NP	
04	6813	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
04	6817	Yes	NA	Yes	500 mL Poly - Unpres	NP	
04	6821	Yes	NA	Yes	250 mL Poly - Unpres	NP	

2nd Review
Are barcode labels on correct containers? (Yes) / No

Completed By: Date & Time: 2.4.16 1825
Reviewed By: Date & Time: 2/4/16 1833

ESS Laboratory

Division of Thielsch Engineering, Inc.

185 Frances Avenue, Cranston RI 02910-2211
Tel. (401)461-7181 Fax (401)461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 160247

Turn Time _____Standard Other_____

Regulatory State: MA RI CT NH NJ NY ME Other_____

Is this project for any of the following:(please circle)
MA-MCP Navy USACE CT DEP Other_____

Reporting Limits - _____

Electonic Deliverables *Excel Access PDF

Co. Name AECOM	Project #	Project Name	
Contact Person Mark Ower	Proj. Location		
Address 9 Jonathan Bourne Dr	City, State Pocasset MA	Zip	PO #
Tel. 781-561-5558	email: mark.ower@aecom.com		

ESS Lab ID	Date	Collection Time	Grab -G Composite-C	Matrix	Sample ID	Pres Code	# of Containers	Type of Container	Vol of Container	Analysis: Amm + TN	NO_2, NO_3, Cl, Alk	DOC	Dis metals	Boron					
1	02/04/16	1255	G	W	MW-A3-B		5			X	X	X	X	X					
2	02/04/16	1430	G	W	MW-A3-A		3			X	X		X						
3	02/04/16	1340	G	W	MW-A3C		3			X	X		X						
4	02/04/16	1540			MW-5		3			X	X		X						
	~~02/04/16~~	~~BKM~~																	

BKM 02/04/16

Cooler Present ✓ Yes ____ No Internal Use Only

Seals Intact ____ Yes ____ No NA: ✓ [✓] Pickup

Cooler Temperature: 1.0 Iced [ ] Technician____

Sampled by :

Comments:

Relinquished by: (Signature, Date & Time)	Received by: (Signature, Date & Time)	Relinquished by: (Signature, Date & Time)	Received by: (Signature, Date & Time)
BKM 02/04/16 1657	02/04/16 1657	2/4/16 1814	2.4.16 1817
Relinquished by: (Signature, Date & Time)	Received by: (Signature, Date & Time)	Relinquished by: (Signature, Date & Time)	Received by: (Signature, Date & Time)

* By circling MA-MCP, client acknowledges sampels were collected in accordance with MADEP CAM VIIA

Please fax to the laboratory all changes to Chain of Custody

Report Method Blank & Laboratory Control Sample Results

CERTIFICATE OF ANALYSIS

Mark Owens
AECOM Environment - ENSR
9 Jonathon Bourne Dr.
Pocasset, MA 02559

RE: Orleans MA (6047664 Task 03.3)
ESS Laboratory Work Order Number: 1602238

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.



Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 12:30 pm, Feb 25, 2016

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with NELAC Standards, A2LA and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602238

SAMPLE RECEIPT

The following samples were received on February 11, 2016 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
1602238-01	MW-6	Aqueous	200.7, 350.1, 353.2, 4500N, 5310B, 9038, 9250
1602238-02	MW-1	Aqueous	200.7, 350.1, 353.2, 4500N, 9038, 9250
1602238-03	MW-E6-A	Aqueous	200.7, 350.1, 353.2, 4500N, 5310B, 9038, 9250
1602238-04	MW-E6-B	Aqueous	200.7, 350.1, 353.2, 4500N, 5310B, 9038, 9250
1602238-05	MW-E6-B-DUP	Aqueous	200.7, 350.1, 353.2, 4500N, 5310B, 9038, 9250
1602238-06	MW-E6-C	Aqueous	200.7, 350.1, 353.2, 4500N, 5310B, 9038, 9250

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602238

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602238

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015D - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH / VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035 - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-6
Date Sampled: 02/10/16 13:45
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-01
Sample Matrix: Aqueous
Units: mg/L

Extraction Method: 3005A

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.05)		200.7		1	KJK	02/13/16 0:03	50	25	CB61208
Manganese	**0.02** (0.01)		200.7		1	KJK	02/13/16 0:03	50	25	CB61208

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-6
Date Sampled: 02/10/16 13:45
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-01
Sample Matrix: Aqueous
Units: mg/L

Extraction Method: 3005A

All methods used are in accordance with 40 CFR 136.

Total Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Boron	ND (0.050)		200.7		1	KJK	02/12/16 23:06	50	25	CB61208

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-6
Date Sampled: 02/10/16 13:45
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-01
Sample Matrix: Aqueous

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	ND (0.10)		350.1		1	EEM	02/16/16 15:52	mg/L	CB61225
Chloride	**114** (15.0)		9250		5	EEM	02/16/16 12:14	mg/L	CB61624
Dissolved Organic Carbon (Average)	**0.906** (0.500)		5310B		1	NAR	02/12/16 19:48	mg/L	[CALC]
Nitrate as N	**1.88** (0.110)		353.2		5	EEM	02/11/16 16:13	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EEM	02/11/16 14:39	mg/L	CB61117
Sulfate	**41.0** (25.0)		9038		5	EEM	02/16/16 17:00	mg/L	CB61625
Total Nitrogen	**2.11** (0.300)		4500N		5	JLK	02/17/16 17:38	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-1
Date Sampled: 02/10/16 14:00
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-02
Sample Matrix: Aqueous
Units: mg/L

Extraction Method: 3005A

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.08** (0.05)		200.7		1	KJK	02/13/16 0:07	50	25	CB61208
Manganese	**0.04** (0.01)		200.7		1	KJK	02/13/16 0:07	50	25	CB61208

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-1
Date Sampled: 02/10/16 14:00
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-02
Sample Matrix: Aqueous

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	ND (0.10)		350.1		1	EEM	02/16/16 15:53	mg/L	CB61225
Chloride	**292** (15.0)		9250		5	EEM	02/16/16 12:16	mg/L	CB61624
Nitrate as N	**1.53** (0.110)		353.2		5	EEM	02/11/16 16:14	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EEM	02/11/16 14:40	mg/L	CB61117
Sulfate	ND (5.0)		9038		1	EEM	02/16/16 17:00	mg/L	CB61625
Total Nitrogen	**1.87** (0.300)		4500N		5	JLK	02/17/16 17:40	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-E6-A
Date Sampled: 02/10/16 16:00
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-03
Sample Matrix: Aqueous
Units: mg/L

Extraction Method: 3005A

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.05)		200.7		1	KJK	02/13/16 0:24	50	25	CB61208
Manganese	**0.04** (0.01)		200.7		1	KJK	02/13/16 0:24	50	25	CB61208

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-E6-A
Date Sampled: 02/10/16 16:00
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-03
Sample Matrix: Aqueous
Units: mg/L

Extraction Method: 3005A

All methods used are in accordance with 40 CFR 136.

Total Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Boron	**0.166** (0.050)		200.7		1	KJK	02/12/16 23:10	50	25	CB61208

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-E6-A
Date Sampled: 02/10/16 16:00
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-03
Sample Matrix: Aqueous

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	ND (0.10)		350.1		1	EEM	02/16/16 15:54	mg/L	CB61225
Chloride	**143** (15.0)		9250		5	EEM	02/16/16 12:17	mg/L	CB61624
Dissolved Organic Carbon (Average)	**8.67** (0.500)		5310B		1	NAR	02/12/16 21:01	mg/L	[CALC]
Nitrate as N	**11.6** (2.01)		353.2		100	EEM	02/11/16 16:15	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EEM	02/11/16 14:41	mg/L	CB61117
Sulfate	**55.5** (25.0)		9038		5	EEM	02/16/16 17:00	mg/L	CB61625
Total Nitrogen	**12.6** (2.20)		4500N		100	JLK	02/17/16 17:41	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-E6-B
Date Sampled: 02/10/16 16:20
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-04
Sample Matrix: Aqueous
Units: mg/L

Extraction Method: 3005A

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.05** (0.05)		200.7		1	KJK	02/13/16 0:29	50	25	CB61208
Manganese	**0.02** (0.01)		200.7		1	KJK	02/13/16 0:29	50	25	CB61208

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-E6-B
Date Sampled: 02/10/16 16:20
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-04
Sample Matrix: Aqueous
Units: mg/L

Extraction Method: 3005A

All methods used are in accordance with 40 CFR 136.

Total Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Boron	**0.141** (0.050)		200.7		1	KJK	02/12/16 23:28	50	25	CB61208

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-E6-B
Date Sampled: 02/10/16 16:20
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-04
Sample Matrix: Aqueous

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	ND (0.10)		350.1		1	EEM	02/16/16 15:54	mg/L	CB61225
Chloride	**115** (15.0)		9250		5	EEM	02/16/16 12:17	mg/L	CB61624
Dissolved Organic Carbon (Average)	**7.61** (0.500)		5310B		1	NAR	02/12/16 21:14	mg/L	[CALC]
Nitrate as N	**20.8** (2.01)		353.2		100	EEM	02/11/16 16:16	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EEM	02/11/16 14:42	mg/L	CB61117
Sulfate	**52.5** (25.0)		9038		5	EEM	02/16/16 17:00	mg/L	CB61625
Total Nitrogen	**21.2** (2.20)		4500N		100	JLK	02/17/16 17:41	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-E6-B-DUP
Date Sampled: 02/10/16 16:25
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-05
Sample Matrix: Aqueous
Units: mg/L

Extraction Method: 3005A

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.05)		200.7		1	KJK	02/13/16 0:33	50	25	CB61208
Manganese	**0.02** (0.01)		200.7		1	KJK	02/13/16 0:33	50	25	CB61208

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-E6-B-DUP
Date Sampled: 02/10/16 16:25
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-05
Sample Matrix: Aqueous
Units: mg/L

Extraction Method: 3005A

All methods used are in accordance with 40 CFR 136.

Total Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Boron	**0.125** (0.050)		200.7		1	KJK	02/12/16 23:32	50	25	CB61208

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-E6-B-DUP
Date Sampled: 02/10/16 16:25
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-05
Sample Matrix: Aqueous

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	ND (0.10)		350.1		1	EEM	02/16/16 15:55	mg/L	CB61225
Chloride	**118** (15.0)		9250		5	EEM	02/16/16 12:18	mg/L	CB61624
Dissolved Organic Carbon (Average)	**7.52** (0.500)		5310B		1	NAR	02/12/16 21:26	mg/L	[CALC]
Nitrate as N	**19.8** (2.01)		353.2		100	EEM	02/11/16 16:17	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EEM	02/11/16 14:43	mg/L	CB61117
Sulfate	**57.0** (25.0)		9038		5	EEM	02/16/16 17:00	mg/L	CB61625
Total Nitrogen	**20.1** (2.20)		4500N		100	JLK	02/17/16 17:42	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-E6-C
Date Sampled: 02/10/16 16:55
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-06
Sample Matrix: Aqueous
Units: mg/L

Extraction Method: 3005A

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.05)		200.7		1	KJK	02/13/16 0:38	50	25	CB61208
Manganese	**0.01** (0.01)		200.7		1	KJK	02/13/16 0:38	50	25	CB61208

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-E6-C
Date Sampled: 02/10/16 16:55
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-06
Sample Matrix: Aqueous
Units: mg/L

Extraction Method: 3005A

All methods used are in accordance with 40 CFR 136.

Total Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Boron	**0.140** (0.050)		200.7		1	KJK	02/12/16 23:36	50	25	CB61208

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-E6-C
Date Sampled: 02/10/16 16:55
Percent Solids: N/A

ESS Laboratory Work Order: 1602238
ESS Laboratory Sample ID: 1602238-06
Sample Matrix: Aqueous

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	ND (0.10)		350.1		1	EEM	02/16/16 15:58	mg/L	CB61225
Chloride	**156** (15.0)		9250		5	EEM	02/16/16 12:18	mg/L	CB61624
Dissolved Organic Carbon (Average)	**8.33** (0.500)		5310B		1	NAR	02/12/16 22:04	mg/L	[CALC]
Nitrate as N	**19.0** (2.01)		353.2		100	EEM	02/11/16 16:18	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EEM	02/11/16 14:45	mg/L	CB61117
Sulfate	**56.0** (25.0)		9038		5	EEM	02/16/16 17:00	mg/L	CB61625
Total Nitrogen	**19.8** (2.20)		4500N		100	JLK	02/17/16 17:43	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602238

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch CB61208 - 3005A										
Blank										
Iron	ND	0.05	mg/L							
Manganese	ND	0.01	mg/L							
LCS										
Iron	1.3	0.05	mg/L	1.250		101	80-120			
Manganese	0.3	0.01	mg/L	0.2500		102	80-120			
LCS Dup										
Iron	1.3	0.05	mg/L	1.250		102	80-120	1	20	
Manganese	0.3	0.01	mg/L	0.2500		103	80-120	0.8	20	
Total Metals										
Batch CB61208 - 3005A										
Blank										
Boron	ND	0.050	mg/L							
LCS										
Boron	0.252	0.050	mg/L	0.2500		101	85-115			
LCS Dup										
Boron	0.258	0.050	mg/L	0.2500		103	85-115	2	20	
Classical Chemistry										
Batch CB61117 - [CALC]										
Blank										
Nitrate as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrate as N	ND		mg/L							
Nitrite as N	0.263		mg/L	0.2497		105	90-110			
Nitrite as N	0.263		mg/L	0.2497		105	90-110			
Batch CB61118 - [CALC]										
Blank										
Nitrate as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
Total Nitrogen	ND	0.020	mg/L							
LCS										
Nitrate as N	0.502		mg/L							
Nitrate/Nitrite as N	0.502		mg/L	0.5000		100	90-110			
Nitrate/Nitrite as N	0.502		mg/L	0.5000		100	90-110			
Total Nitrogen	0.502		mg/L							
Batch CB61225 - NH4 Prep										

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602238

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Classical Chemistry										
Batch CB61225 - NH4 Prep										
Blank										
Ammonia as N	ND	0.10	mg/L							
LCS										
Ammonia as N	0.11	0.10	mg/L	0.09994		114	80-120			
LCS										
Ammonia as N	0.95	0.10	mg/L	0.9994		95	80-120			
Batch CB61235 - General Preparation										
Blank										
Dissolved Organic Carbon (1)	ND	0.500	mg/L							
Dissolved Organic Carbon (2)	ND	0.500	mg/L							
Dissolved Organic Carbon (Average)	ND	0.500	mg/L							
LCS										
Dissolved Organic Carbon (1)	4.70	0.500	mg/L	5.000		94	80-120			
Dissolved Organic Carbon (2)	4.73	0.500	mg/L	5.000		95	80-120			
Dissolved Organic Carbon (Average)	4.71	0.500	mg/L							
LCS Dup										
Dissolved Organic Carbon (1)	4.88	0.500	mg/L	5.000		98	80-120	4	200	
Dissolved Organic Carbon (2)	4.88	0.500	mg/L	5.000		98	80-120	3	200	
Dissolved Organic Carbon (Average)	4.88	0.500	mg/L							
Batch CB61624 - General Preparation										
Blank										
Chloride	ND	3.0	mg/L							
LCS										
Chloride	29.2		mg/L	30.00		97	90-110			
Batch CB61625 - General Preparation										
Blank										
Sulfate	ND	5.0	mg/L							
LCS										
Sulfate	9.5		mg/L	9.988		95	85-115			
Batch CB61638 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
Total Nitrogen	ND	0.200	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	18.0	2.00	mg/L	17.60		102	80-120			
Total Nitrogen	18.0	2.00	mg/L							

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602238

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602238

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/water/dwp-services/labcert/documents/AllLabs.xls

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

United States Department of Agriculture Soil Permit: P330-12-00139

Pennsylvania: 68-01752
http://www.depweb.state.pa.us/portal/server.pt/community/labs/13780/laboratory_accreditation_program/590095

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB/MM

Shipped/Delivered Via: ESS Courier

ESS Project ID: 1602238
Date Received: 2/11/2016
Project Due Date: 2/19/2016
Days for Project: 5 Day

1. Air bill manifest present? Yes
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 5.3 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** (Yes) / No / NA
10. Were any analyses received outside of hold time? Yes / (No)

11. Any Subcontracting needed? Yes / (No)
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / (No)
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA

13. Are the samples properly preserved? (Yes) / No
    a. If metals preserved in SR: Date: Time: By:
    b. Low Level VOAs brought to freezer: Date: Time: By:

Sample Receiving Notes:

Was there a need to contact the client? Yes / No
Who was contacted? Date: Time: By:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
01	7723	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
01	7724	Yes	NA	Yes	500 mL Poly - Unpres	NP	
01	7725	Yes	NA	Yes	250 mL Poly - HNO3	HNO3	
01	7726	Yes	NA	Yes	250 mL Poly - Unpres	NP	
01	7727	Yes	NA	Yes	250 mL Amber - Unpres	NP	
01	7758	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4	
01	7759	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4	
02	7728	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
02	7729	Yes	NA	Yes	500 mL Poly - Unpres	NP	
02	7730	Yes	NA	Yes	250 mL Poly - Unpres	NP	
03	7734	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
03	7738	Yes	NA	Yes	500 mL Poly - Unpres	NP	
03	7742	Yes	NA	Yes	250 mL Poly - HNO3	HNO3	
03	7746	Yes	NA	Yes	250 mL Poly - Unpres	NP	
03	7750	Yes	NA	Yes	250 mL Amber - Unpres	NP	
03	7766	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4	
03	7767	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4	
04	7733	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
04	7737	Yes	NA	Yes	500 mL Poly - Unpres	NP	
04	7741	Yes	NA	Yes	250 mL Poly - HNO3	HNO3	
04	7745	Yes	NA	Yes	250 mL Poly - Unpres	NP	
04	7749	Yes	NA	Yes	250 mL Amber - Unpres	NP	
04	7764	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4	

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB/MM

ESS Project ID: 1602238

Date Received: 2/11/2016

04	7765	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4
05	7732	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
05	7736	Yes	NA	Yes	500 mL Poly - Unpres	NP
05	7740	Yes	NA	Yes	250 mL Poly - HNO3	HNO3
05	7744	Yes	NA	Yes	250 mL Poly - Unpres	NP
05	7748	Yes	NA	Yes	250 mL Amber - Unpres	NP
05	7762	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4
05	7763	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4
06	7731	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
06	7735	Yes	NA	Yes	500 mL Poly - Unpres	NP
06	7739	Yes	NA	Yes	250 mL Poly - HNO3	HNO3
06	7743	Yes	NA	Yes	250 mL Poly - Unpres	NP
06	7747	Yes	NA	Yes	250 mL Amber - Unpres	NP
06	7760	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4
06	7761	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4

2nd Review

Are barcode labels on correct containers? (Yes) / No

Completed By: Larissa Badger Date & Time: 2/11/16 1045

Reviewed By: [signature] Date & Time: 2/11/16 1105

ESS Laboratory

Division of Thielsch Engineering, Inc.

185 Frances Avenue, Cranston RI 02910-2211
Tel. (401)461-7181 Fax (401)461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 1602238

Turn Time _____ Standard Other_____

Regulatory State: MA RI CT NH NJ NY ME Other_____

Is this project for any of the following:(please circle)
MA-MCP Navy USACE CT DEP Other_____

Reporting Limits - _____

Electonic Deliverables *Excel Access PDF

Co. Name	AECOM
Contact Person	Mark Owen
Address	9 Jonathan Bourne Dr.
City, State	Pocasset, MA
Zip	02559
PO #	
Tel.	774-644-1124
email:	mark.owen@aecom.com
Project #	60476044
Project Name	
Proj. Location	Orleans, MA

ESS Lab ID	Date	Collection Time	Grab -G Composite-C	Matrix	Sample ID	Pres Code	# of Containers	Type of Container	Vol of Contaner	Analysis: NO3, NO2, chloride, sulfate	Ammonia + TN	DOC	Dissolved metals	Boron				
1	02/10/16	13:45	G	W	MW-6		5			X	X	X	X	X				
2	02/10/16	14:00	G	W	MW-1		3			X	X		X					
3	02/10/16	16:00	G	W	MW-E6-A		5			X	X	X	X	X				
4	02/10/16	16:20	G	W	MW-E6-B		5			X	X	X	X	X				
5	02/10/16	16:25	G	W	MW-E6-B-DUP		5			X	X	X	X	X				
6	02/10/16	16:55	G	W	MW-E6-C		5			X	X	X	X	X				

Cooler Present ___Yes ___No Internal Use Only

Seals Intact ___Yes ___No NA: —

Cooler Temperature: 5.3 - 1.0 = 4.3 2/11/16 [ ] Pickup [ ] Technician___

Sampled by :

Comments:

Relinquished by: (Signature, Date & Time)	Received by: (Signature, Date & Time)	Relinquished by: (Signature, Date & Time)	Received by: (Signature, Date & Time)
Brittany Morrill 02/11/16 0815	2/11/16	2/11/16	2/11/16 Laura Bodge 1004
Relinquished by: (Signature, Date & Time)	Received by: (Signature, Date & Time)	Relinquished by: (Signature, Date & Time)	Received by: (Signature, Date & Time)

Please fax to the laboratory all changes to Chain of Custody

* By circling MA-MCP, client acknowledges samples were collected in accordance with MADEP CAM VIIA

Report Method Blank & Laboratory Control Sample Results

CERTIFICATE OF ANALYSIS

Mark Owens
AECOM Environment - ENSR
9 Jonathon Bourne Dr.
Pocasset, MA 02559

RE: Orleans MA (6047664 Task 03.3)
ESS Laboratory Work Order Number: 1602594

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 3:07 pm, Mar 04, 2016

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with NELAC Standards, A2LA and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602594

SAMPLE RECEIPT

The following samples were received on February 26, 2016 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
1602594-01	MW-A1-C	Ground Water	350.1, 353.2, 4500N, 5310B, 9038, 9250
1602594-02	MW-A1-C-2	Ground Water	350.1, 353.2, 4500N, 5310B, 9038, 9250
1602594-03	MW-2S	Ground Water	200.7, 350.1, 353.2, 4500N, 5310B, 9038, 9250
1602594-04	MW-2D	Ground Water	200.7, 350.1, 353.2, 4500N, 5310B, 9038, 9250
1602594-05	MW-5S	Ground Water	350.1, 353.2, 4500N, 9038, 9250
1602594-06	MW-5D	Ground Water	350.1, 353.2, 4500N, 9038, 9250

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602594

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602594

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015D - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH / VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035 - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A1-C
Date Sampled: 02/26/16 15:35
Percent Solids: N/A

ESS Laboratory Work Order: 1602594
ESS Laboratory Sample ID: 1602594-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	**0.15** (0.10)		350.1		1	EEM	03/03/16 11:28	mg/L	CC60243
Chloride	**72.4** (3.0)		9250		1	JLK	02/29/16 16:54	mg/L	CB62946
Dissolved Organic Carbon (Average)	**4.11** (0.500)		5310B		1	DEL	03/03/16 18:44	mg/L	[CALC]
Nitrate as N	**0.128** (0.030)		353.2		1	JLK	02/26/16 20:40	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	02/26/16 20:28	mg/L	CB62617
Sulfate	ND (5.0)		9038		1	JLK	02/29/16 17:25	mg/L	CB62948
Total Nitrogen	**0.820** (0.220)		4500N		1	JLK	03/03/16 21:28	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-A1-C-2
Date Sampled: 02/26/16 15:40
Percent Solids: N/A

ESS Laboratory Work Order: 1602594
ESS Laboratory Sample ID: 1602594-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	**0.25** (0.10)		350.1		1	EEM	03/03/16 11:29	mg/L	CC60243
Chloride	**72.8** (3.0)		9250		1	JLK	02/29/16 16:56	mg/L	CB62946
Dissolved Organic Carbon (Average)	**4.84** (0.500)		5310B		1	DEL	03/03/16 0:33	mg/L	[CALC]
Nitrate as N	**0.124** (0.030)		353.2		1	JLK	02/26/16 20:41	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	02/26/16 20:29	mg/L	CB62617
Sulfate	ND (5.0)		9038		1	JLK	02/29/16 17:25	mg/L	CB62948
Total Nitrogen	**0.818** (0.220)		4500N		1	JLK	03/03/16 21:29	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-2S
Date Sampled: 02/26/16 12:05
Percent Solids: N/A

ESS Laboratory Work Order: 1602594
ESS Laboratory Sample ID: 1602594-03
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 3005A

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.1)		200.7		1	KJK	03/03/16 21:55	50	50	CC60302
Manganese	**0.6** (0.02)		200.7		1	KJK	03/03/16 21:55	50	50	CC60302

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-2S
Date Sampled: 02/26/16 12:05
Percent Solids: N/A

ESS Laboratory Work Order: 1602594
ESS Laboratory Sample ID: 1602594-03
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 3005A

All methods used are in accordance with 40 CFR 136.

Total Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Boron	**0.223** (0.050)		200.7		1	KJK	03/02/16 4:46	50	25	CC60103

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-2S
Date Sampled: 02/26/16 12:05
Percent Solids: N/A

ESS Laboratory Work Order: 1602594
ESS Laboratory Sample ID: 1602594-03
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	**0.25** (0.10)		350.1		1	EEM	03/03/16 11:29	mg/L	CC60243
Chloride	**131** (6.0)		9250		2	JLK	02/29/16 17:01	mg/L	CB62946
Dissolved Organic Carbon (Average)	**9.46** (0.500)		5310B		1	DEL	03/03/16 0:45	mg/L	[CALC]
Nitrate as N	**24.7** (1.01)		353.2		50	JLK	02/26/16 20:49	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	02/26/16 20:30	mg/L	CB62617
Sulfate	**66.0** (25.0)		9038		5	JLK	02/29/16 17:25	mg/L	CB62948
Total Nitrogen	**27.1** (1.20)		4500N		50	JLK	03/03/16 21:29	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-2D
Date Sampled: 02/26/16 12:00
Percent Solids: N/A

ESS Laboratory Work Order: 1602594
ESS Laboratory Sample ID: 1602594-04
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 3005A

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.1)		200.7		1	KJK	03/03/16 22:00	50	50	CC60302
Manganese	**1.1** (0.02)		200.7		1	KJK	03/03/16 22:00	50	50	CC60302

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-2D
Date Sampled: 02/26/16 12:00
Percent Solids: N/A

ESS Laboratory Work Order: 1602594
ESS Laboratory Sample ID: 1602594-04
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 3005A

All methods used are in accordance with 40 CFR 136.

Total Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Boron	**0.156** (0.050)		200.7		1	KJK	03/02/16 4:50	50	25	CC60103

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-2D
Date Sampled: 02/26/16 12:00
Percent Solids: N/A

ESS Laboratory Work Order: 1602594
ESS Laboratory Sample ID: 1602594-04
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	**0.34** (0.10)		350.1		1	EEM	03/03/16 11:30	mg/L	CC60243
Chloride	**152** (6.0)		9250		2	JLK	02/29/16 17:01	mg/L	CB62946
Dissolved Organic Carbon (Average)	**4.51** (0.500)		5310B		1	DEL	03/03/16 19:39	mg/L	[CALC]
Nitrate as N	**9.26** (0.210)		353.2		10	JLK	02/26/16 20:47	mg/L	[CALC]
Nitrite as N	**0.065** (0.010)		353.2		1	JLK	02/26/16 20:31	mg/L	CB62617
Sulfate	**51.6** (10.0)		9038		2	JLK	02/29/16 17:25	mg/L	CB62948
Total Nitrogen	**11.1** (0.400)		4500N		10	JLK	03/03/16 21:30	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-5S
Date Sampled: 02/26/16 13:30
Percent Solids: N/A

ESS Laboratory Work Order: 1602594
ESS Laboratory Sample ID: 1602594-05
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	ND (0.10)		350.1		1	EEM	03/03/16 11:33	mg/L	CC60243
Chloride	**53.1** (3.0)		9250		1	JLK	02/29/16 16:59	mg/L	CB62946
Nitrate as N	**0.034** (0.030)		353.2		1	JLK	02/26/16 20:44	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	02/26/16 20:32	mg/L	CB62617
Sulfate	**27.9** (5.0)		9038		1	JLK	02/29/16 17:25	mg/L	CB62948
Total Nitrogen	**1.78** (0.220)		4500N		1	JLK	03/03/16 21:33	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-5D
Date Sampled: 02/26/16 13:10
Percent Solids: N/A

ESS Laboratory Work Order: 1602594
ESS Laboratory Sample ID: 1602594-06
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	**15.3** (2.00)		350.1		20	EEM	03/03/16 11:40	mg/L	CC60243
Chloride	**61.2** (3.0)		9250		1	JLK	02/29/16 17:00	mg/L	CB62946
Nitrate as N	**11.4** (0.410)		353.2		20	JLK	02/26/16 20:56	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	02/26/16 20:33	mg/L	CB62617
Sulfate	**45.2** (10.0)		9038		2	JLK	02/29/16 17:25	mg/L	CB62948
Total Nitrogen	**26.8** (2.40)		4500N		20	JLK	03/03/16 21:38	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602594

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch CC60302 - 3005A										
Blank										
Iron	ND	0.1	mg/L							
Manganese	ND	0.02	mg/L							
LCS										
Iron	2.5	0.1	mg/L	2.500		101	80-120			
Manganese	0.5	0.02	mg/L	0.5000		105	80-120			
LCS Dup										
Iron	2.5	0.1	mg/L	2.500		99	80-120	2	20	
Manganese	0.5	0.02	mg/L	0.5000		100	80-120	5	20	
Total Metals										
Batch CC60103 - 3005A										
Blank										
Boron	ND	0.050	mg/L							
LCS										
Boron	0.230	0.050	mg/L	0.2500		92	85-115			
LCS Dup										
Boron	0.236	0.050	mg/L	0.2500		94	85-115	3	20	
Classical Chemistry										
Batch CB62617 - [CALC]										
Blank										
Nitrate as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrate as N	ND		mg/L							
Nitrite as N	0.257		mg/L	0.2497		103	90-110			
Nitrite as N	0.257		mg/L	0.2497		103	90-110			
Batch CB62618 - [CALC]										
Blank										
Nitrate as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
Total Nitrogen	ND	0.020	mg/L							
LCS										
Nitrate as N	0.524		mg/L							
Nitrate/Nitrite as N	0.524		mg/L	0.5000		105	90-110			
Nitrate/Nitrite as N	0.524		mg/L	0.5000		105	90-110			
Total Nitrogen	0.524		mg/L							
Batch CB62946 - General Preparation										

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602594

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Classical Chemistry										
Batch CB62946 - General Preparation										
Blank										
Chloride	ND	3.0	mg/L							
LCS										
Chloride	28.4		mg/L	30.00		95	90-110			
Batch CB62948 - General Preparation										
Blank										
Sulfate	ND	5.0	mg/L							
LCS										
Sulfate	9.5		mg/L	9.988		95	85-115			
Batch CC60228 - General Preparation										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
Total Nitrogen	ND	0.200	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	8.52	1.00	mg/L	8.030		106	80-120			
Total Nitrogen	8.52	1.00	mg/L							
Batch CC60243 - NH4 Prep										
Blank										
Ammonia as N	ND	0.10	mg/L							
LCS										
Ammonia as N	0.09	0.10	mg/L	0.09994		90	80-120			
LCS										
Ammonia as N	0.93	0.10	mg/L	0.9994		93	80-120			
Batch CC60256 - General Preparation										
Blank										
Dissolved Organic Carbon (1)	ND	0.500	mg/L							
Dissolved Organic Carbon (2)	ND	0.500	mg/L							
Dissolved Organic Carbon (Average)	ND	0.500	mg/L							
LCS										
Dissolved Organic Carbon (1)	4.84	0.500	mg/L	5.000		97	80-120			
Dissolved Organic Carbon (2)	4.60	0.500	mg/L	5.000		92	80-120			
Dissolved Organic Carbon (Average)	4.72	0.500	mg/L							
LCS Dup										
Dissolved Organic Carbon (1)	4.49	0.500	mg/L	5.000		90	80-120	8	200	
Dissolved Organic Carbon (2)	4.44	0.500	mg/L	5.000		89	80-120	4	200	
Dissolved Organic Carbon (Average)	4.47	0.500	mg/L							

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602594

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1602594

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/water/dwp-services/labcert/documents/AllLabs.xls

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

United States Department of Agriculture Soil Permit: P330-12-00139

Pennsylvania: 68-01752
http://www.depweb.state.pa.us/portal/server.pt/community/labs/13780/laboratory_accreditation_program/590095

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB/MM

Shipped/Delivered Via: ESS Courier

ESS Project ID: 1602594
Date Received: 2/26/2016
Project Due Date: 3/4/2016
Days for Project: 5 Day

1. Air bill manifest present? Yes
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 2.4 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? No
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** (Yes) / No / ~~NA~~ JS 2/26/16
10. Were any analyses received outside of hold time? Yes / (No)

11. Any Subcontracting needed? Yes / (No)
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / (No)
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / (NA)

13. Are the samples properly preserved? (Yes) No
    a. If metals preserved upon receipt: Date: Time: By:
    b. Low Level VOAs brought to freezer: Date: Time: By:

Sample Receiving Notes:

① MW-5D NO ANALYSIS CHECKED OFF.
② MW-5S CHECKED FOR DOC. NO CONTAINER PROVIDED.

14. Was there a need to contact Project Manager? (Yes) No
    a. Was there a need to contact the client? (Yes) No
    Who was contacted? J. Marrion Date: 2/29/16 Time: 0923 By: mkm - email

    updated coc with correct analysis for samples MW-5S and MW-5D

(TT) 2.26.16

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
01	12546	Yes	NA	Yes	250 mL Amber - Unpres	NP	
01	12552	Yes	NA	Yes	500 mL Poly - Unpres	NP	
01	12558	Yes	NA	Yes	500 mL Poly - H2SO4	H2SO4	
01	12633	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4	
01	12634	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4	
02	12545	Yes	NA	Yes	250 mL Amber - Unpres	NP	
02	12551	Yes	NA	Yes	500 mL Poly - Unpres	NP	
02	12557	Yes	NA	Yes	500 mL Poly - H2SO4	H2SO4	
02	12631	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4	
02	12632	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4	
03	12544	Yes	NA	Yes	250 mL Amber - Unpres	NP	
03	12550	Yes	NA	Yes	500 mL Poly - Unpres	NP	
03	12556	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
03	12560	Yes	NA	Yes	250 mL Poly - HNO3	HNO3	
03	12562	Yes	NA	Yes	250 mL Poly - Unpres	NP	
03	12629	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4	
03	12630	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4	
04	12543	Yes	NA	Yes	250 mL Amber - Unpres	NP	
04	12549	Yes	NA	Yes	500 mL Poly - Unpres	NP	
04	12555	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
04	12559	Yes	NA	Yes	250 mL Poly - HNO3	HNO3	
04	12561	Yes	NA	Yes	250 mL Poly - Unpres	NP	
04	12627	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4	

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB/MM

ESS Project ID: 1602594

Date Received: 2/26/2016

04	12628	Yes	NA	Yes	VOA Vial - H2SO4	H2SO4
05	12542	Yes	NA	Yes	250 mL Poly - Unpres	NP
05	12548	Yes	NA	Yes	500 mL Poly - Unpres	NP
05	12554	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
06	12541	Yes	NA	Yes	250 mL Poly - Unpres	NP
06	12547	Yes	NA	Yes	500 mL Poly - Unpres	NP
06	12553	Yes	NA	Yes	1L Poly - H2SO4	H2SO4

2nd Review

Are barcode labels on correct containers? (Yes / No)

Completed By: _____ Date & Time: 2.26.16 1945

Reviewed By: _____ Date & Time: 2/26/16 2017

ESS Laboratory

Division of Thielsch Engineering, Inc.

185 Frances Avenue, Cranston RI 02910-2211
Tel. (401)461-7181 Fax (401)461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 1602594

Turn Time _____ Standard Other_____

Regulatory State: MA RI CT NH NJ NY ME Other_____

Is this project for any of the following:(please circle)
MA-MCP Navy USACE CT DEP Other_____

Reporting Limits - _____

Electonic Deliverables *Excel Access PDF

Co. Name	Project #	Project Name
AECOM		

Contact Person	Proj. Location
Mark Owen	Orleans

Address	City, State	Zip	PO #
4 Jonathan Bourne DR	Pocasset MA	02559	

Tel.	email:
	mark.owen@aecom.com

ESS Lab ID	Date	Collection Time	Grab -G Composite-C	Matrix	Sample ID	Pres Code	# of Containers	Type of Container	Vol of Container	Analysis: Ammn+ TN	Nitrate, Nitrite, Sulfate	DO C	Dissolved Metals	Boron					
1	02/26/16	1535	G	GW	MW-A1-C		3			X	X	X							
2	02/26/16	15:40	G	GW	MW-A1-C-2		3			X	X	X							
3	02/26/16	12:05	G	GW	MW-2S		3/5			X	X	X	X	X					
4	02/26/16	1200	G	GW	MW-2D		5			X	X	X	X	X					
5	02/26/16	1330	G	GW	MW-5S		3			X	X	X							
6	02/26/16	1310	G	GW	MW-5D		3			X	X								

Cooler Present ✓ Yes _____ No

Seals Intact ____ Yes _____ No NA: ✓

Cooler Temperature: 2.4 ice RB

Internal Use Only
[✓] Pickup
[ ] Technician____

Sampled by :

Comments: Per B.M. sample analysis updated mkm 2/29/16 0948

Relinquished by: (Signature, Date & Time)	Received by: (Signature, Date & Time)	Relinquished by: (Signature, Date & Time)	Received by: (Signature, Date & Time)
Bailey Mundell 02/26/16 1645	2/26/16 16:45	2/26/16 18:20	2.26.16 1830

* By circling MA-MCP, client acknowledges sampels were collected in accordance with MADEP CAM VIIA

Please fax to the laboratory all changes to Chain of Custody

Report Method Blank & Laboratory Control Sample Results

ESS Laboratory

Division of Thielsch Engineering, Inc.

185 Frances Avenue, Cranston RI 02910-2211
Tel. (401)461-7181 Fax (401)461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 1602594

Turn Time _____ Standard Other_____

Regulatory State: MA RI CT NH NJ NY ME Other_____

Is this project for any of the following:(please circle)
MA-MCP Navy USACE CT DEP Other_____

Reporting Limits - _____

Electonic Deliverables *Excel Access PDF

Co. Name	Project #	Project Name
AECOM		

Contact Person	Proj. Location
Mark Owen	Orleans

Address	City, State	Zip	PO #
4 Jonathan Bourne DR	Pocasset MA	02559	

Tel.	email:
	mark.owen@aecom.com

ESS Lab ID	Date	Collection Time	Grab -G Composite-C	Matrix	Sample ID	Pres Code	# of Containers	Type of Container	Vol of Container	Analysis: Ammn+ TN	Nitrate, Nitrite, SU	DOC	Dissolved Metals	Boron
1	02/26/16	1535	G	GW	MW-A1-C		3			X	X	X		
2	02/26/16	15:40	G	GW	MW-A1-C-2		3			X	X	X		
3	02/26/16	12:05	G	GW	MW-2S		3/5			X	X	X	X	X
4	02/26/16	1200	G	GW	MW-2D		5			X	X	X	X	X
5	02/26/16	1330	G	GW	MW-5S		3			X	X	X		
6	02/26/16	1310	G	GW	MW-5D		3							

Cooler Present ✓ Yes ____ No

Seals Intact ____ Yes ____ No NA: ✓

Cooler Temperature: 2.4 ice RB

Internal Use Only
[✓] Pickup
[ ] Technician____

Sampled by :

Comments:

Relinquished by: (Signature, Date & Time)	Received by: (Signature, Date & Time)	Relinquished by: (Signature, Date & Time)	Received by: (Signature, Date & Time)
Bailey Mundell 02/26/16 1645	2/26/16 16:45	2/26/16 18:20	2.26.16 1830

* By circling MA-MCP, client acknowledges sampels were collected in accordance with MADEP CAM VIIA

Please fax to the laboratory all changes to Chain of Custody

Report Method Blank & Laboratory Control Sample Results

Nauset Regional Middle School Groundwater Quality Monitoring

Quarterly Report January 2016

File. C12854.00

GROUNDWATER QUALITY MONITORING PROGRAM
QUARTERLY REPORT

NAUSET REGIONAL MIDDLE SCHOOL
Route 28
Orleans, MA

For the Quarter Ending
December 2015

Prepared for:
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

On behalf of:
NAUSET REGIONAL SCHOOL DISTRICT
78 Eldredge Park Way
Orleans, MA 02653

Prepared by:
COASTAL ENGINEERING CO., INC.
260 Cranberry Highway
Orleans, MA 02653

COASTAL
engineering co.

APPENDIX A: Plan GW-4P Groundwater Monitoring Site Plan
APPENDIX B: Chemical Groundwater Analysis 01/07/16 & 01/12/16
APPENDIX C: Water Quality Summary Tables

COASTAL
engineering co.

January 20, 2016

Project No. C12854.00

Mr. Glenn Haas
Department of Environmental Protection
Division of Water Pollution Control
One Winter Street
Boston, MA 02108
T: (617) 756-7281 F: (617) 755-2267

RE: Nauset Regional Middle School
Route 28/Chatham Road, Orleans, MA
Groundwater Monitoring Program
September 2015

Dear Mr. Haas:

Coastal Engineering Co., Inc. (CEC), as agent for the Nauset Regional School District (NRSD), has prepared this quarterly report for tracking groundwater quality at the above-referenced site, based on a letter dated February 6, 1992 from the Department of Environmental Protection (DEP). Included are a summary table of nutrient concentrations, the laboratory test results for the groundwater samples collected at monitoring wells MW-2, MW-4, MW-8, MW-11, MW-11S, and MW-12 and a groundwater contour plan, GW-4P, showing historic and present static water levels for the quarter ending December 31, 2015.

Sampling of the onsite monitoring wells was conducted on December 30, 2015. Each well was purged and sampled using a submersible pump. Samples for nitrogen series, alkalinity, chloride and volatile organic compounds (VOC's) were collected and sent by courier to Rhode Island Analytical Laboratories.

Groundwater gauging levels were as follows:

	EL TOP OF CASING	DEPTH TO WATER	SWL (NGVD)
MW-1	42.48	29.34	13.14
MW-2	46.00	33.23	12.77
MW-4	47.75	35.35	12.25
MW-8	47.26	35.00	12.26
MW-11	46.28	33.76	12.52
MW-11S	46.42	33.84	12.58
MW-12	47.26	35 33	11.93

The enclosed Groundwater Monitoring Site Plan depicts the groundwater contours and the resultant hydraulic gradient. Measured groundwater levels are much the same as the previous quarter due to the lack of precipitation typical for this time of year. The groundwater direction is generally to the southeast; away from Boland Pond.

The laboratory analyses are included in Appendix B. A cumulative record of the analytical test results is included in Appendix C. Grab samples were also collected and tested onsite for pH and specific conductivity using portable testing meters. The field testing results for pH and conductivity are provided on Table 1 in Appendix B. All monitor well samples show pH levels between 5.79 to 6.20, reflecting the naturally high acidity of the groundwater.

Chemical analysis of the monitoring wells tested shows that total nitrogen levels for all wells are below the State Drinking Water Standard for total nitrogen. The highest total nitrogen was found in monitor well MW-8, which tested at 9.08 mg/L, which is below the discharge limit of 10 mg/L. The MW-8 well is the only well located in the middle of the athletic field and likely sources of additional nitrogen to this well are applied fertilizer and geese feces. The nitrate level in MW-2, which is in the parking lot, is the lowest of all wells sampled. Alkalinity and chloride levels were similar in all wells sampled, except the chloride levels in MW-2 are higher due to residuals from nearby storm drains. All monitor wells tested for VOC's were found below detection limits. Water usage has been updated because the water meters are now accessible after new construction around the meter pit.

Water usage figures are included in the table below.

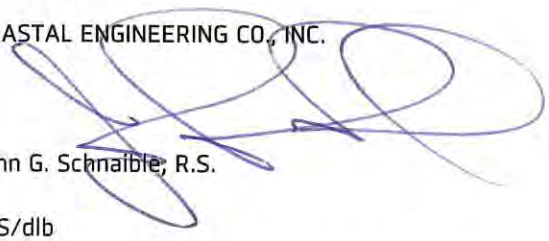
Date	Readings	Flow	Days (total)	School days	Gallons per day
12/12/12	2601800/4970120	198,750	63	42	4732*
1/7/13	2618200/4997580	43,860	26	12	3655*
3/26/13	2680800/5100940	165,960	78	55	3017*
6/18/13	2753100/5218470	189830	84	55	3451*
7/16/13	2761700/5239070	29,200	28	--	1043
9/25/13	2785600/5299280	84,110	71	--	1185
10/7/13	2795800/5315260	26,180	12	8	3272*
1/10/14	2866800/5420180	175,920	95	59	2982*
3/25/15	3227000/5944570	--	--	--	**
6/9/15	3310300/6052970	191,700	75	50	3834*
9/17/15	3352600/6130400	119,730	100	22	1197
12/30/15	3453000/6200260	170,260	104	64	2660*
01/19/16	3470250/6277500	94,490	20	12	7874*

* Denotes water usage based on school days. Holidays/weekends and summer vacation days are excluded.
** Denotes first usage readings that were accessible after construction.

Should you have any questions or comments regarding these findings or need additional information, please contact me at your earliest convenience. The next quarterly round of sampling is scheduled for March 2016.

Very truly yours,

COASTAL ENGINEERING CO., INC.



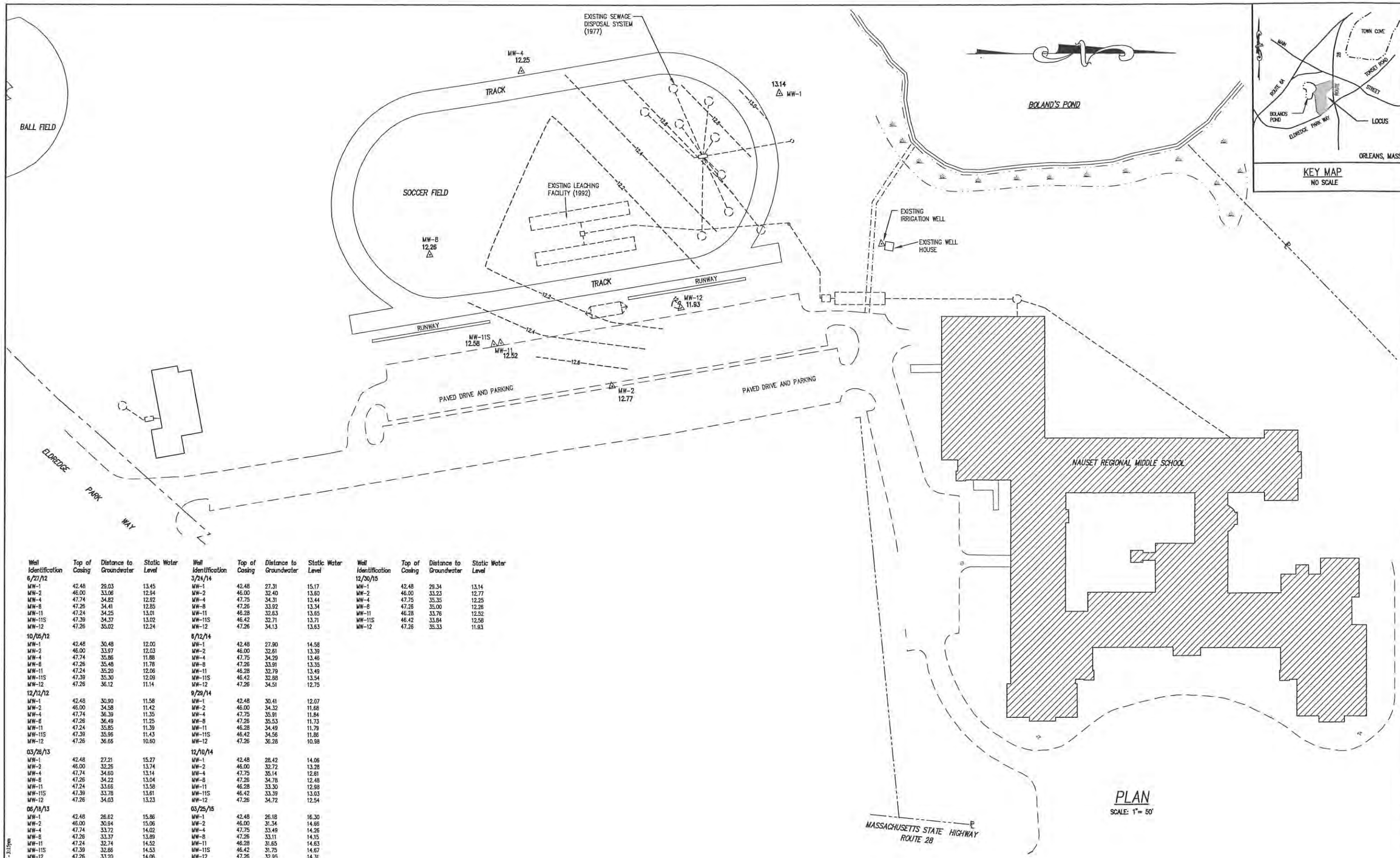
John G. Schnaible, R.S.

JGS/dlb

cc: Giovanna Venditti, Business Manager, NRSD
Jeffrey Gould, MA-DEP-SERO-DWPC
Robert Canning, Orleans Health Agent

APPENDIX A

GROUNDWATER MONITORING SITE PLAN



Well Identification	Top of Casing	Distance to Groundwater	Static Water Level
6/27/12			
MW-1	42.48	29.03	13.45
MW-2	46.00	33.06	12.94
MW-4	47.74	34.82	12.92
MW-8	47.26	34.41	12.85
MW-11	47.24	34.23	13.01
MW-11S	47.39	34.37	13.02
MW-12	47.26	35.02	12.24
10/05/12			
MW-1	42.48	30.48	12.00
MW-2	46.00	33.97	12.03
MW-4	47.74	35.86	11.88
MW-8	47.26	35.48	11.78
MW-11	47.24	35.20	12.06
MW-11S	47.39	35.30	12.09
MW-12	47.26	36.12	11.14
12/12/12			
MW-1	42.48	30.90	11.58
MW-2	46.00	34.58	11.42
MW-4	47.74	36.39	11.35
MW-8	47.26	36.49	11.25
MW-11	47.24	35.85	11.39
MW-11S	47.39	35.96	11.43
MW-12	47.26	36.65	10.60
03/26/13			
MW-1	42.48	27.21	15.27
MW-2	46.00	32.26	13.74
MW-4	47.74	34.60	13.14
MW-8	47.26	34.22	13.04
MW-11	47.24	33.66	13.58
MW-11S	47.39	33.78	13.61
MW-12	47.26	34.03	13.23
06/18/13			
MW-1	42.48	26.62	15.86
MW-2	46.00	30.94	15.06
MW-4	47.74	33.72	14.02
MW-8	47.26	33.37	13.89
MW-11	47.24	32.74	14.52
MW-11S	47.39	32.86	14.53
MW-12	47.26	33.20	14.06
09/18/13			
MW-1	42.48	28.40	14.08
MW-2	46.00	32.61	13.39
MW-4	47.74	34.37	13.37
MW-8	47.26	33.99	13.27
MW-11	47.24	33.75	13.49
MW-11S	47.39	N/A (DAMAGED)	N/A (DAMAGED)
MW-12	47.26	34.62	12.64
12/18/13			
MW-1	42.48	29.87	12.61
MW-2	46.00	33.63	12.37
MW-4	47.75	35.62	12.13
MW-8	47.26	35.25	12.01
MW-11	46.28	34.13	12.15
MW-11S	46.42	34.22	12.20
MW-12	47.26	35.80	11.46

Well Identification	Top of Casing	Distance to Groundwater	Static Water Level
3/24/14			
MW-1	42.48	27.31	15.17
MW-2	46.00	32.40	13.60
MW-4	47.75	34.31	13.44
MW-8	47.26	33.92	13.34
MW-11	46.28	32.63	13.65
MW-11S	46.42	32.71	13.71
MW-12	47.26	34.13	13.63
6/12/14			
MW-1	42.48	27.90	14.58
MW-2	46.00	32.61	13.39
MW-4	47.75	34.29	13.46
MW-8	47.26	33.91	13.35
MW-11	46.28	32.79	13.49
MW-11S	46.42	32.88	13.54
MW-12	47.26	34.51	12.75
9/29/14			
MW-1	42.48	30.41	12.07
MW-2	46.00	34.32	11.68
MW-4	47.75	35.91	11.84
MW-8	47.26	35.53	11.73
MW-11	46.28	34.49	11.79
MW-11S	46.42	34.56	11.86
MW-12	47.26	36.28	10.98
12/10/14			
MW-1	42.48	28.42	14.06
MW-2	46.00	32.72	13.28
MW-4	47.75	35.14	12.61
MW-8	47.26	34.78	12.48
MW-11	46.28	33.30	12.98
MW-11S	46.42	33.39	13.03
MW-12	47.26	34.72	12.54
03/25/15			
MW-1	42.48	26.18	16.30
MW-2	46.00	31.34	14.66
MW-4	47.75	33.49	14.26
MW-8	47.26	33.11	14.15
MW-11	46.28	31.65	14.63
MW-11S	46.42	31.75	14.67
MW-12	47.26	32.95	14.31
06/18/15			
MW-1	42.48	27.40	15.08
MW-2	46.00	31.93	14.07
MW-4	47.75	33.50	14.25
MW-8	47.26	33.14	14.12
MW-11	46.28	32.05	14.23
MW-11S	46.42	32.15	14.27
MW-12	47.26	33.86	13.40
09/17/15			
MW-1	42.48	29.30	13.18
MW-2	46.00	33.16	12.84
MW-4	47.75	35.04	12.71
MW-8	47.26	34.84	12.42
MW-11	46.28	33.50	12.78
MW-11S	46.42	33.57	12.85
MW-12	47.26	35.27	11.99

Well Identification	Top of Casing	Distance to Groundwater	Static Water Level
12/30/15			
MW-1	42.48	29.34	13.14
MW-2	46.00	33.23	12.77
MW-4	47.75	35.35	12.25
MW-8	47.26	35.00	12.26
MW-11	46.28	33.76	12.52
MW-11S	46.42	33.84	12.58
MW-12	47.26	35.33	11.93

COASTAL ENGINEERING COMPANY, INC.
260 Cranberry Hwy. Orleans, MA 02653
508.255.6511 Fax: 508.255.6700

NO.	DATE	REVISION	BY

SEAL

PROJECT
NAUSET REGIONAL MIDDLE SCHOOL
ELDREDGE PARK WAY & ROUTE 28
ORLEANS, MA

SHEET TITLE
GROUNDWATER MONITORING SITE PLAN

SCALE	1" = 50'
DRAWING FILE	C12854.dwg
DATE	01-08-16
DRAWN BY	MAP
CHECKED BY	

GW-4P

1 OF 1 SHEETS

PROJECT NO. C12854.00

Coastal Engineering Co., Inc. © 2016

P:\WORKPROJECT\2009\C12854\C12854.dwg Jan 08, 2016 - 3:15pm

APPENDIX B

LABORATORY REPORT
GROUNDWATER TEST RESULTS

R.I. ANALYTICAL
Specialists in Environmental Services

CERTIFICATE OF ANALYSIS

Coastal Engineering Co., Inc.
Attn: Mr. Chad Simmons
260 Cranberry Highway
Orleans, MA 02653

Date Received: 12/30/2015
Date Reported: 1/12/2016
P.O. #:
Work Order #: 1512-28289

DESCRIPTION: PROJECT# C12-854.00 NAUSET REGIONAL MIDDLE SCHOOL

Subject sample(s) has/have been analyzed by our Warwick, RI laboratory with the attached results.

Reference: All parameters were analyzed by U.S. EPA approved methodologies.
The specific methodologies are listed in the methods column of the Certificate of Analysis.

Data qualifiers (if present) are explained in full at the end of a given sample's analytical results.
The Detection Limit is defined as the lowest level that can be reliably achieved during routine laboratory conditions.
The Certificate of Analysis shall not be reproduced except in full, without written approval of R.I. Analytical.
Results relate only to samples submitted to the laboratory for analysis.
Test results are not blank corrected.

Certification # (as applicable to the sample's origin state):
RI LAI0033, MA M-RI015, CT PH-0508, ME RI00015, NH 2537, NY 11726

If you have any questions regarding this work, or if we may be of further assistance, please contact our customer service department.

Approved by:

enc: Chain of Custody

R.I. Analytical Laboratories, Inc.

CERTIFICATE OF ANALYSIS

Coastal Engineering Co., Inc.
Date Received: 12/30/2015
Work Order #: 1512-28289

Sample # 001
SAMPLE DESCRIPTION: MW-2
SAMPLE TYPE:GRAB **SAMPLE DATE/TIME:** 12/30/2015 @ 10:30

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
Nitrite (as N)	<0.20	0.20	mg/l	EPA 300.0	12/30/2015 23:57	JDC
Nitrate (as N)	1.1	0.20	mg/l	EPA 300.0	12/30/2015 23:57	JDC
Chloride	68	2.5	mg/l	EPA 300.0	12/30/2015 23:57	JDC
Alkalinity (as CaCO3)	20	1.0	mg/l	SM2320B 18-21ed	12/30/2015 19:00	JJG
TKN (as N)	<0.50	0.50	mg/l	SM4500NOrg-D 18-21ed	1/7/2016 17:11	JGL
Ammonia (as N)	<0.10	0.10	mg/l	SM4500NH3-B,H 18-21ed	1/5/2016 18:50	APD

Sample # 002
SAMPLE DESCRIPTION: MW-4
SAMPLE TYPE:GRAB **SAMPLE DATE/TIME:** 12/30/2015 @ 08:45

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
Nitrite (as N)	<0.20	0.20	mg/l	EPA 300.0	12/31/2015 12:11	JDC
Nitrate (as N)	4.2	0.20	mg/l	EPA 300.0	12/31/2015 12:11	JDC
Chloride	20	2.5	mg/l	EPA 300.0	12/31/2015 12:11	JDC
Alkalinity (as CaCO3)	18	1.0	mg/l	SM2320B 18-21ed	12/30/2015 19:00	JJG
TKN (as N)	<0.60	0.50	mg/l	SM4500NOrg-D 18-21ed	1/7/2016 17:11	JGL
Ammonia (as N)	<0.60	0.10	mg/l	SM4500NH3-B,H 18-21ed	1/5/2016 18:50	APD

The container for Alkalinity analysis was not received filled as required by methodology. Sample was analyzed as received.

Sample # 003
SAMPLE DESCRIPTION: MW-8
SAMPLE TYPE:GRAB **SAMPLE DATE/TIME:** 12/30/2015 @ 09:15

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
Nitrite (as N)	<0.20	0.20	mg/l	EPA 300.0	12/31/2015 12:25	JDC
Nitrate (as N)	8.2	0.20	mg/l	EPA 300.0	12/31/2015 12:25	JDC
Chloride	16	2.5	mg/l	EPA 300.0	12/31/2015 12:25	JDC
Alkalinity (as CaCO3)	10	1.0	mg/l	SM2320B 18-21ed	12/30/2015 19:00	JJG
TKN (as N)	0.88	0.50	mg/l	SM4500NOrg-D 18-21ed	1/7/2016 17:11	JGL
Ammonia (as N)	0.17	0.10	mg/l	SM4500NH3-B,H 18-21ed	1/5/2016 18:50	APD

R.I. Analytical Laboratories, Inc.

CERTIFICATE OF ANALYSIS

Coastal Engineering Co., Inc.
Date Received: 12/30/2015
Work Order #: 1512-28289

Sample # 004
SAMPLE DESCRIPTION: MW-11
SAMPLE TYPE:GRAB **SAMPLE DATE/TIME:** 12/30/2015 @ 09:40

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
Nitrite (as N)	<0.20	0.20	mg/l	EPA 300.0	12/31/2015 12:39	JDC
Nitrate (as N)	7.3	0.20	mg/l	EPA 300.0	12/31/2015 12:39	JDC
Chloride	24	2.5	mg/l	EPA 300.0	12/31/2015 12:39	JDC
Alkalinity (as CaCO3)	10	1.0	mg/l	SM2320B 18-21ed	12/30/2015 19:00	JJG
TKN (as N)	<0.50	0.50	mg/l	SM4500NOrg-D 18-21ed	1/7/2016 17:11	JGL
Ammonia (as N)	0.14	0.10	mg/l	SM4500NH3-B,H 18-21ed	1/5/2016 18:50	APD

The container for Alkalinity analysis was not received filled as required by methodology. Sample was analyzed as received.

Sample # 005
SAMPLE DESCRIPTION: MW-11S
SAMPLE TYPE:GRAB **SAMPLE DATE/TIME:** 12/30/2015 @ 09:50

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
Nitrite (as N)	<0.20	0.20	mg/l	EPA 300.0	12/31/2015 12:52	JDC
Nitrate (as N)	8.0	0.20	mg/l	EPA 300.0	12/31/2015 12:52	JDC
Chloride	26	2.5	mg/l	EPA 300.0	12/31/2015 12:52	JDC
Alkalinity (as CaCO3)	5.1	1.0	mg/l	SM2320B 18-21ed	12/30/2015 19:00	JJG
TKN (as N)	<0.50	0.50	mg/l	SM4500NOrg-D 18-21ed	1/7/2016 17:11	JGL
Ammonia (as N)	0.49	0.10	mg/l	SM4500NH3-B,H 18-21ed	1/5/2016 18:50	APD

Sample # 006
SAMPLE DESCRIPTION: MW-12
SAMPLE TYPE:GRAB **SAMPLE DATE/TIME:** 12/30/2015 @ 10:15

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
Nitrite (as N)	<0.20	0.20	mg/l	EPA 300.0	12/31/2015 1:20	JDC
Nitrate (as N)	8.0	0.20	mg/l	EPA 300.0	12/31/2015 1:20	JDC
Chloride	24	2.5	mg/l	EPA 300.0	12/31/2015 1:20	JDC
Alkalinity (as CaCO3)	8.1	1.0	mg/l	SM2320B 18-21ed	12/30/2015 19:00	JJG
TKN (as N)	<0.50	0.50	mg/l	SM4500NOrg-D 18-21ed	1/7/2016 17:11	JGL
Ammonia (as N)	0.12	0.10	mg/l	SM4500NH3-B,H 18-21ed	1/5/2016 18:50	APD

R.I. ANALYTICAL
Specialists in Environmental Services

CHAIN OF CUSTODY RECORD

41 Illinois Avenue
Warwick, RI 02888-3007
800-937-2580 • Fax: 401-738-1970

131 Coolidge St., Suite 105
Hudson, MA 01749-1331
800-937-2580 • Fax: 978-568-0078

09-21-10

Date Collected	Time Collected	Field Sample Identification	Grab or Composite	# of Containers & Type C	Preservation Code P	Matrix Code M	NO_3 / NO_3 / Cl / Alk	TKN, Amm
12/30/15	10:30A	MW-2	G	1P	NP	GW	X	
	10:30A	MW-2	G	1P	S	GW		X
*	8:45A	MW-4	G	1P	NP	GW	X	
	8:45A	MW-4	G	1P	S	GW		X
	9:15A	MW-8	G	1P	NP	GW	X	
	9:15A	MW-8	G	1P	S	GW		X
*	9:40A	MW-11	G	1P	NP	GW	X	
	9:40A	MW-11	G	1P	S	GW		X
	9:50A	MW-11S	G	1P	NP	GW	X	
	9:50A	MW-11S	G	1P	S	GW		X
	10:15A	MW-12	G	2P	NP	GW	X	
	10:15A	MW-12	G	1P	S	GW		X
				13				

Client Information

Company Name: Coastal Engineering Company, Inc.
Address: 260 Cranberry Hwy
City / State / Zip: Orleans, MA 02653
Telephone: 508 255-6511 Fax: 508 255-6700
Contact Person: Chad A Simmons

Project Information

Project Name: NAUSET Regional Middle School
P.O. Number: Project Number: C12-854.00
Report To: Chad Simmons Phone: 508 255-6511 Fax 508 255-6700
Sampled By: K. Rezendes
Email report to these addresses: CSimmons@CoastalEngineeringCompany.com
Quote No: COA 120913

Relinquished By Signatures	Date	Time	Received By Signatures	Date	Time
	12/30/15	1110		12/30/15	1110
	12/30/15	1545		12/30/15	15:45

Turn Around Time

- [X] Normal [ ] EMAIL Report
- [ ] 5 Business days. Possible surcharge
- [ ] Rush – Date Due: ___/___/___

Project Comments

Circle if applicable: GW-1, GW-2, GW-3, S-1, S-2, S-3 MCP Data Enhancement QC Package? Yes No

* BOTTLES HAVE HEADSPACE – JK

Temp. Upon Receipt 2.6 °C

Lab Use Only

- [X] Sample Pick-Up Only
- [ ] RIAL sampled; attach field hours
- [X] Shipped on ice

Workorder No: 1512-28289

Containers: P=Poly, G=Glass, AG=Amber Glass, V=Vial, St=Sterile Preservatives: A=Ascorbic Acid, NH4=NH_4Cl, H=HCl, M=MeOH, N=HNO_3, NP=None, S=H_2SO_4, SB=$NaHSO_4$, SH=NaOH, T=$Na_2S_2O_3$, Z=ZnOAc
Matrix Codes: GW=Groundwater, SW=Surface Water, WW=Wastewater, DW=Drinking Water, S=Soil, SL=Sludge, A=Air, B=Bulk/Solid, WP=Wipe O=_____

R.I. ANALYTICAL
Specialists in Environmental Services

RECEIVED
JAN 13 2016
Coastal Engineering Co., Inc.

CERTIFICATE OF ANALYSIS

Coastal Engineering Co., Inc.
Attn: Mr. Todd Palmatier
260 Cranberry Highway
Orleans, MA 02653

Date Received: 12/30/2015
Date Reported: 1/7/2016
P.O. #:
Work Order #: 1512-28290

DESCRIPTION: PROJECT# C12854.00 NAUSET REGIONAL MIDDLE SCHOOL

Subject sample(s) has/have been analyzed by our Warwick, RI laboratory with the attached results.

Reference: All parameters were analyzed by U.S. EPA approved methodologies.
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Data qualifiers (if present) are explained in full at the end of a given sample's analytical results.
The Detection Limit is defined as the lowest level that can be reliably achieved during routine laboratory conditions.
The Certificate of Analysis shall not be reproduced except in full, without written approval of R.I. Analytical.
Results relate only to samples submitted to the laboratory for analysis.
Test results are not blank corrected.

Certification # (as applicable to the sample's origin state):
RI LAI0033, MA M-RI015, CT PH-0508, ME RI00015, NH 2537, NY 11726

If you have any questions regarding this work, or if we may be of further assistance, please contact our customer service department.

Approved by:

enc: Chain of Custody

R.I. Analytical Laboratories, Inc.

CERTIFICATE OF ANALYSIS

Coastal Engineering Co., Inc.
Date Received: 12/30/2015
Work Order #: 1512-28290

Sample # 001
SAMPLE DESCRIPTION: MW-2
SAMPLE TYPE:GRAB **SAMPLE DATE/TIME:** 12/30/2015 @ 10:30

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
Volatile Organic Compounds						
Chloromethane	<10	10	ug/l	EPA 624	12/31/2015 19:43	KF
Bromomethane	<10	10	ug/l	EPA 624	12/31/2015 19:43	KF
Vinyl Chloride	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
Chloroethane	<10	10	ug/l	EPA 624	12/31/2015 19:43	KF
Methylene Chloride	<5	5	ug/l	EPA 624	12/31/2015 19:43	KF
Trichlorofluoromethane	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
1,1-Dichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
1,1-Dichloroethane	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
trans-1,2-Dichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
Chloroform	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
1,2-Dichloroethane	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
1,1,1-Trichloroethane	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
Carbon Tetrachloride	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
Bromodichloromethane	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
1,2-Dichloropropane	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
cis-1,3-Dichloropropylene	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
Trichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
trans-1,3-Dichloropropylene	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
1,1,2-Trichloroethane	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
Dibromochloromethane	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
Bromoform	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
Tetrachloroethylene	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
1,1,2,2-Tetrachloroethane	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
Chlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
2-Chloroethyl vinyl ether	<2	2	ug/l	EPA 624	12/31/2015 19:43	KF
1,2-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
1,3-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
1,4-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
Benzene	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
Toluene	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
Ethylbenzene	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
o-Xylene	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
m,p-Xylene	<1	1	ug/l	EPA 624	12/31/2015 19:43	KF
Acetone	<10	10	ug/l	EPA 624	12/31/2015 19:43	KF
Surrogates			RANGE	EPA 624	12/31/2015 19:43	KF
Dibromofluoromethane	102		86-118%	EPA 624	12/31/2015 19:43	KF
Toluene-D8	102		88-110%	EPA 624	12/31/2015 19:43	KF
4-Bromofluorobenzene	101		86-115%	EPA 624	12/31/2015 19:43	KF

R.I. Analytical Laboratories, Inc.

CERTIFICATE OF ANALYSIS

Coastal Engineering Co., Inc.
Date Received: 12/30/2015
Work Order #: 1512-28290

Sample # 002
SAMPLE DESCRIPTION: MW-4
SAMPLE TYPE:GRAB
SAMPLE DATE/TIME: 12/30/2015 @ 08:45

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
Volatile Organic Compounds						
Chloromethane	<10	10	ug/l	EPA 624	12/31/2015 20:10	KF
Bromomethane	<10	10	ug/l	EPA 624	12/31/2015 20:10	KF
Vinyl Chloride	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
Chloroethane	<10	10	ug/l	EPA 624	12/31/2015 20:10	KF
Methylene Chloride	<5	5	ug/l	EPA 624	12/31/2015 20:10	KF
Trichlorofluoromethane	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
1,1-Dichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
1,1-Dichloroethane	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
trans-1,2-Dichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
Chloroform	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
1,2-Dichloroethane	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
1,1,1-Trichloroethane	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
Carbon Tetrachloride	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
Bromodichloromethane	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
1,2-Dichloropropane	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
cis-1,3-Dichloropropylene	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
Trichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
trans-1,3-Dichloropropylene	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
1,1,2-Trichloroethane	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
Dibromochloromethane	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
Bromoform	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
Tetrachloroethylene	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
1,1,2,2-Tetrachloroethane	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
Chlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
2-Chloroethyl vinyl ether	<2	2	ug/l	EPA 624	12/31/2015 20:10	KF
1,2-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
1,3-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
1,4-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
Benzene	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
Toluene	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
Ethylbenzene	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
o-Xylene	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
m,p-Xylene	<1	1	ug/l	EPA 624	12/31/2015 20:10	KF
Acetone	<10	10	ug/l	EPA 624	12/31/2015 20:10	KF
Surrogates			RANGE	EPA 624	12/31/2015 20:10	KF
Dibromofluoromethane	101		86-118%	EPA 624	12/31/2015 20:10	KF
Toluene-D8	101		88-110%	EPA 624	12/31/2015 20:10	KF
4-Bromofluorobenzene	99		86-115%	EPA 624	12/31/2015 20:10	KF

R.I. Analytical Laboratories, Inc.

CERTIFICATE OF ANALYSIS

Coastal Engineering Co., Inc.
Date Received: 12/30/2015
Work Order #: 1512-28290

Sample # 003
SAMPLE DESCRIPTION: MW-8
SAMPLE TYPE:GRAB **SAMPLE DATE/TIME:** 12/30/2015 @ 09:15

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
Volatile Organic Compounds						
Chloromethane	<10	10	ug/l	EPA 624	12/31/2015 20:37	KF
Bromomethane	<10	10	ug/l	EPA 624	12/31/2015 20:37	KF
Vinyl Chloride	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
Chloroethane	<10	10	ug/l	EPA 624	12/31/2015 20:37	KF
Methylene Chloride	<5	5	ug/l	EPA 624	12/31/2015 20:37	KF
Trichlorofluoromethane	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
1,1-Dichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
1,1-Dichloroethane	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
trans-1,2-Dichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
Chloroform	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
1,2-Dichloroethane	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
1,1,1-Trichloroethane	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
Carbon Tetrachloride	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
Bromodichloromethane	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
1,2-Dichloropropane	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
cis-1,3-Dichloropropylene	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
Trichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
trans-1,3-Dichloropropylene	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
1,1,2-Trichloroethane	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
Dibromochloromethane	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
Bromoform	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
Tetrachloroethylene	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
1,1,2,2-Tetrachloroethane	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
Chlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
2-Chloroethyl vinyl ether	<2	2	ug/l	EPA 624	12/31/2015 20:37	KF
1,2-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
1,3-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
1,4-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
Benzene	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
Toluene	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
Ethylbenzene	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
o-Xylene	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
m,p-Xylene	<1	1	ug/l	EPA 624	12/31/2015 20:37	KF
Acetone	<10	10	ug/l	EPA 624	12/31/2015 20:37	KF
Surrogates			RANGE	EPA 624	12/31/2015 20:37	KF
Dibromofluoromethane	102		86-118%	EPA 624	12/31/2015 20:37	KF
Toluene-D8	101		88-110%	EPA 624	12/31/2015 20:37	KF
4-Bromofluorobenzene	101		86-115%	EPA 624	12/31/2015 20:37	KF

R.I. Analytical Laboratories, Inc.

CERTIFICATE OF ANALYSIS

Coastal Engineering Co., Inc.
Date Received: 12/30/2015
Work Order #: 1512-28290

Sample # 004
SAMPLE DESCRIPTION: MW-11
SAMPLE TYPE:GRAB **SAMPLE DATE/TIME:** 12/30/2015 @ 09:40

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
Volatile Organic Compounds						
Chloromethane	<10	10	ug/l	EPA 624	12/31/2015 21:05	KF
Bromomethane	<10	10	ug/l	EPA 624	12/31/2015 21:05	KF
Vinyl Chloride	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
Chloroethane	<10	10	ug/l	EPA 624	12/31/2015 21:05	KF
Methylene Chloride	<5	5	ug/l	EPA 624	12/31/2015 21:05	KF
Trichlorofluoromethane	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
1,1-Dichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
1,1-Dichloroethane	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
trans-1,2-Dichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
Chloroform	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
1,2-Dichloroethane	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
1,1,1-Trichloroethane	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
Carbon Tetrachloride	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
Bromodichloromethane	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
1,2-Dichloropropane	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
cis-1,3-Dichloropropylene	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
Trichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
trans-1,3-Dichloropropylene	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
1,1,2-Trichloroethane	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
Dibromochloromethane	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
Bromoform	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
Tetrachloroethylene	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
1,1,2,2-Tetrachloroethane	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
Chlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
2-Chloroethyl vinyl ether	<2	2	ug/l	EPA 624	12/31/2015 21:05	KF
1,2-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
1,3-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
1,4-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
Benzene	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
Toluene	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
Ethylbenzene	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
o-Xylene	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
m,p-Xylene	<1	1	ug/l	EPA 624	12/31/2015 21:05	KF
Acetone	<10	10	ug/l	EPA 624	12/31/2015 21:05	KF
Surrogates			RANGE	EPA 624	12/31/2015 21:05	KF
Dibromofluoromethane	101		86-118%	EPA 624	12/31/2015 21:05	KF
Toluene-D8	102		88-110%	EPA 624	12/31/2015 21:05	KF
4-Bromofluorobenzene	100		86-115%	EPA 624	12/31/2015 21:05	KF

R.I. Analytical Laboratories, Inc.

CERTIFICATE OF ANALYSIS

Coastal Engineering Co., Inc.
Date Received: 12/30/2015
Work Order #: 1512-28290

Sample # 005
SAMPLE DESCRIPTION: MW-11S
SAMPLE TYPE:GRAB **SAMPLE DATE/TIME:** 12/30/2015 @ 09:50

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
Volatile Organic Compounds						
Chloromethane	<10	10	ug/l	EPA 624	12/31/2015 21:32	KF
Bromomethane	<10	10	ug/l	EPA 624	12/31/2015 21:32	KF
Vinyl Chloride	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
Chloroethane	<10	10	ug/l	EPA 624	12/31/2015 21:32	KF
Methylene Chloride	<5	5	ug/l	EPA 624	12/31/2015 21:32	KF
Trichlorofluoromethane	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
1,1-Dichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
1,1-Dichloroethane	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
trans-1,2-Dichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
Chloroform	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
1,2-Dichloroethane	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
1,1,1-Trichloroethane	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
Carbon Tetrachloride	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
Bromodichloromethane	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
1,2-Dichloropropane	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
cis-1,3-Dichloropropylene	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
Trichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
trans-1,3-Dichloropropylene	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
1,1,2-Trichloroethane	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
Dibromochloromethane	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
Bromoform	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
Tetrachloroethylene	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
1,1,2,2-Tetrachloroethane	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
Chlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
2-Chloroethyl vinyl ether	<2	2	ug/l	EPA 624	12/31/2015 21:32	KF
1,2-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
1,3-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
1,4-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
Benzene	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
Toluene	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
Ethylbenzene	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
o-Xylene	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
m,p-Xylene	<1	1	ug/l	EPA 624	12/31/2015 21:32	KF
Acetone	<10	10	ug/l	EPA 624	12/31/2015 21:32	KF
Surrogates			RANGE	EPA 624	12/31/2015 21:32	KF
Dibromofluoromethane	102		86-118%	EPA 624	12/31/2015 21:32	KF
Toluene-D8	102		88-110%	EPA 624	12/31/2015 21:32	KF
4-Bromofluorobenzene	101		86-115%	EPA 624	12/31/2015 21:32	KF

R.I. Analytical Laboratories, Inc.

CERTIFICATE OF ANALYSIS

Coastal Engineering Co., Inc.
Date Received: 12/30/2015
Work Order #: 1512-28290

Sample # 006
SAMPLE DESCRIPTION: MW-12
SAMPLE TYPE:GRAB **SAMPLE DATE/TIME:** 12/30/2015 @ 10:15

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
Volatile Organic Compounds						
Chloromethane	<10	10	ug/l	EPA 624	12/31/2015 21:59	KF
Bromomethane	<10	10	ug/l	EPA 624	12/31/2015 21:59	KF
Vinyl Chloride	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
Chloroethane	<10	10	ug/l	EPA 624	12/31/2015 21:59	KF
Methylene Chloride	<5	5	ug/l	EPA 624	12/31/2015 21:59	KF
Trichlorofluoromethane	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
1,1-Dichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
1,1-Dichloroethane	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
trans-1,2-Dichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
Chloroform	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
1,2-Dichloroethane	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
1,1,1-Trichloroethane	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
Carbon Tetrachloride	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
Bromodichloromethane	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
1,2-Dichloropropane	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
cis-1,3-Dichloropropylene	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
Trichloroethylene	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
trans-1,3-Dichloropropylene	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
1,1,2-Trichloroethane	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
Dibromochloromethane	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
Bromoform	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
Tetrachloroethylene	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
1,1,2,2-Tetrachloroethane	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
Chlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
2-Chloroethyl vinyl ether	<2	2	ug/l	EPA 624	12/31/2015 21:59	KF
1,2-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
1,3-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
1,4-Dichlorobenzene	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
Benzene	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
Toluene	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
Ethylbenzene	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
o-Xylene	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
m,p-Xylene	<1	1	ug/l	EPA 624	12/31/2015 21:59	KF
Acetone	<10	10	ug/l	EPA 624	12/31/2015 21:59	KF
Surrogates			RANGE	EPA 624	12/31/2015 21:59	KF
Dibromofluoromethane	102		86-118%	EPA 624	12/31/2015 21:59	KF
Toluene-D8	101		88-110%	EPA 624	12/31/2015 21:59	KF
4-Bromofluorobenzene	98		86-115%	EPA 624	12/31/2015 21:59	KF

R.I. Analytical Laboratories, Inc.

CERTIFICATE OF ANALYSIS

Coastal Engineering Co., Inc.
Date Received: 12/30/2015
Work Order #: 1512-28290

R.I. ANALYTICAL
Specialists in Environmental Services

CHAIN OF CUSTODY RECORD

41 Illinois Avenue
Warwick, RI 02888-3007
800-937-2580 • Fax: 401-738-1970

131 Coolidge St., Suite 105
Hudson, MA 01749-1331
800-937-2580 • Fax: 978-568-0078

09-21-10

Date Collected	Time Collected	Field Sample Identification	Grab or Composite	# of Containers & Type C	Preservation Code P	Matrix Code M	VOC 624
12/30/15	10:30A	MW-2	G	2V	H	GW	X
	8:45A	MW-4	G	2V	H	GW	X
	9:15A	MW-8	G	2V	H	GW	X
	9:40A	MW-11	G	2V	H	GW	X
	9:50A	MW-11S	G	2V	H	GW	X
	10:15A	MW-12	G	2V	H	GW	X

12

Client Information

Company Name: Coastal Engineering Co., Inc
Address: 260 Cranberry Highway
City / State / Zip: Orleans, MA 02653
Telephone: 508 255-6511 Fax: 508 255-6700
Contact Person: Todd Palmatier

Project Information

Project Name: Nauset Regional Middle School
P.O. Number: — Project Number: C12854.00
Report To: Todd Palmatier Phone: 255-6511 Fax 255-6700
Sampled By: ~~Todd Palmatier~~ KEVIN Resendes
Quote No: COA120913
Email report to these addresses: tpalmatier@cecapecod.com

Relinquished By Signatures	Date	Time	Received By Signatures	Date	Time
	12/30/15	1110		12/30/15	1110
	12/30/15	1545		12/30/15	15:45

Turn Around Time

X Normal | EMAIL Report
5 Business days. Possible surcharge
Rush – Date Due: ___/___/___

Project Comments

Circle if applicable: GW-1, GW-2, GW-3, S-1, S-2, S-3 MCP Data Enhancement QC Package? Yes No

* VIALS PRESERVED IN SODIUM THIO.

Temp. Upon Receipt 2.6 °C

Lab Use Only

X Sample Pick-Up Only 28289
X RIAL sampled; attach field hours
X Shipped on ice
Workorder No: 1512-28290

Containers: P=Poly, G=Glass, AG=Amber Glass, V=Vial, St=Sterile Preservatives: A=Ascorbic Acid, NH4=NH_4Cl, H=HCl, M=MeOH, N=HNO_3, NP=None, S=H_2SO_4, SB=$NaHSO_4$, SH=NaOH, T=$Na_2S_2O_3$, Z=ZnOAc
Matrix Codes: GW=Groundwater, SW=Surface Water, WW=Wastewater, DW=Drinking Water, S=Soil, SL=Sludge, A=Air, B=Bulk/Solid, WP=Wipe, O=_____

APPENDIX C

WATER QUALITY SUMMARY TABLES

TABLE 1

ONSITE MONITORING WELL SAMPLING FOR PH AND SPECIFIC CONDUCTIVITY

FILE NO.: C12854.00

LOCATION: NAUSET REGIONAL MIDDLE SCHOOL
ORLEANS, MA

SAMPLE DATE: 12/30/15

SAMPLED AND GAUGED BY: Kevin Rezendes

Parameter	MW-2	MW-4	MW-8	MW-11	MW-11S	MW-12
pH (s.a.)	6.20	5.98	6.13	5.87	5.93	5.88
Specific Conductivity (umhos/c)	420	200	190	220	220	200

NOTE: pH and specific conductivity were field tested by CEC personnel using portable testing meters.

Appendix C

UPGRADIENT AND DOWNGRADIENT WATER QUALITY (NUTRIENT CONCENTRATIONS)

Monitor Well	2/27/1992	7/24/1992	9/15/1992	12/15/1992	3/19/1993	6/17/1993	9/13/1993	12/17/1993	3/31/1994	6/28/1994	9/16/1994	12/19/1994	4/4/1995	6/19/1995
Upgradient														
MW-4														
Nitrate													4.50	1.85
Ammonia													<0.1	<0.1
T Nitrogen													4.50	4.54
TKN													<0.2	2.69
Downgradient														
MW-2														
Nitrate	1.92	1.60	1.10	1.55	1.48	1.34	0.96	2.75	2.15	1.08	1.05	4.65	5.90	5.25
Ammonia	N/A	0.21	<0.05	<0.05	<0.05	<0.01	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1
T Nitrogen	2.38	2.02	1.10	3.55	1.59	1.45	0.96	2.97	2.88	1.19	1.05	4.65	5.90	5.25
TKN	N/A	N/A	N/A	<2.00	0.11	0.11	<0.10	0.22	0.73	0.11	<0.10	<0.10	<0.2	<0.2
MW-8														
Nitrate	1.26	1.29	1.84	2.30	1.10	1.95	1.44	1.20	1.65	1.53	1.85	1.85	2.05	2.40
Ammonia	N/A	0.10	<0.05	<0.05	<0.05	<0.01	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1
T Nitrogen	2.37	1.92	5.84	5.30	1.10	2.29	1.66	1.59	4.79	1.67	1.85	1.85	2.05	2.40
TKN	N/A	N/A	N/A	3.00	<0.10	0.34	0.22	0.39	3.14	0.14	<0.10	<0.10	<0.2	<0.2
MW-11														
Nitrate	5.91	6.58	5.15	4.57	4.53	7.41	5.36	3.95	5.25	5.10	5.50	5.00	3.95	3.05
Ammonia	N/A	0.09	<0.05	<0.05	<0.05	<0.01	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1
T Nitrogen	6.27	6.96	5.15	7.57	4.53	7.41	5.58	3.95	5.25	5.10	5.50	5.00	3.95	3.05
TKN	N/A	N/A	N/A	3.00	<0.10	<0.10	0.22	<0.10	<0.10	<0.10	<0.10	<0.10	<0.2	<0.2
MW-11S														
Nitrate	5.94	5.98	5.65	5.24	4.69	7.16	4.65	3.50	5.35	5.60	6.35	5.35	5.65	4.05
Ammonia	N/A	0.08	<0.05	<0.05	<0.05	<0.01	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1
T Nitrogen	6.56	6.43	9.50	8.24	4.53	7.16	4.65	3.61	5.85	5.99	6.35	5.35	5.65	4.05
TKN	N/A	N/A	N/A	3.00	<0.10	<0.10	<0.10	0.11	0.50	0.39	<0.10	<0.10	<0.2	<0.2
MW-12														
Nitrate	5.32	6.51	6.40	6.61	6.78	7.70	4.16	1.95	5.80	5.65	6.65	5.90	5.65	6.55
Ammonia	N/A	0.10	<0.05	<0.05	<0.05	<0.01	<0.10	<0.20	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1
T Nitrogen	5.84	7.10	6.40	9.61	6.78	7.87	4.16	2.23	6.42	5.65	6.65	5.90	5.65	6.77
TKN	N/A	N/A	N/A	3.00	<0.10	0.17	<0.10	0.28	0.62	<0.10	<0.10	<0.10	<0.2	0.22

D:\DOC\C12800\12854\[Water Quality.xls]Appendix C

Appendix C

UPGRADIENT AND DOWNGRADIENT WATER QUALITY
(NUTRIENT CONCENTRATIONS)

Monitor Well	9/21/1995	12/19/1995	3/13/1996	6/21/1996	9/11/1996	12/17/1996	3/13/1997	6/23/1997	9/11/1997	12/15/1997	3/26/1998	6/22/1998	9/28/1998	12/29/1998
Upgradient														
MW-4														
Nitrate	3.60	2.60	3.05	4.65	4.80	7.75	5.25	5.75	4.40	3.10	2.04	3.20	1.90	1.30
Ammonia	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
T Nitrogen	3.60	2.60	3.05	4.65	4.80	7.75	5.25	5.75	4.40	3.10	2.04	3.20	2.19	1.30
TKN	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.29	<0.2
Downgradient														
MW-2														
Nitrate	8.47	2.85	3.65	5.70	0.90	1.90	2.95	2.35	0.80	1.90	2.40	0.80	1.10	1.30
Ammonia	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
T Nitrogen	8.47	2.85	3.87	5.70	0.90	1.90	3.73	2.35	0.80	1.90	2.40	0.80	0.44	1.30
TKN	<0.2	<0.2	0.22	<0.2	<0.2	<0.2	0.78	<0.2	<0.2	<0.2	<0.2	<0.2	1.54	<0.2
MW-8														
Nitrate	4.20	2.60	4.10	4.65	3.95	8.05	3.25	3.80	--	3.50	3.00	3.10	2.45	1.45
Ammonia	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	<0.1	<0.1	<0.1	<0.1	<0.1
T Nitrogen	4.20	2.60	4.10	4.55	3.95	8.05	3.60	3.80	--	3.50	3.00	3.10	0.29	1.45
TKN	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.35	<0.2	--	<0.2	<0.2	<0.2	2.74	<0.2
MW-11														
Nitrate	4.87	5.55	4.00	4.65	4.90	6.55	5.15	6.40	4.80	5.50	3.20	5.00	3.60	3.30
Ammonia	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
T Nitrogen	4.87	5.55	4.00	4.65	4.90	6.55	5.15	6.40	4.80	5.50	3.20	5.00	3.60	3.30
TKN	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
MW-11S														
Nitrate	4.45	3.00	3.80	4.55	4.95	7.10	7.21	5.65	4.80	6.25	4.40	4.15	3.55	3.80
Ammonia	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
T Nitrogen	4.45	3.00	4.14	4.55	4.95	7.52	7.21	5.65	4.80	7.12	4.40	4.15	3.55	3.80
TKN	<0.2	<0.2	0.34	<0.2	<0.2	0.42	<0.2	<0.2	<0.2	0.87	<0.2	<0.2	<0.2	<0.2
MW-12														
Nitrate	7.20	6.05	6.95	5.80	6.22	6.55	5.95	5.50	4.40	5.00	5.00	4.60	3.90	5.15
Ammonia	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
T Nitrogen	7.20	6.27	6.95	5.80	6.22	6.55	5.95	5.50	4.40	5.00	5.00	4.60	3.90	5.15
TKN	<0.2	0.22	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.1	<0.2

Appendix C

UPGRADIENT AND DOWNGRADIENT WATER QUALITY
(NUTRIENT CONCENTRATIONS)

Monitor Well	3/19/1999	6/29/1999	9/23/1999	12/14/1999	3/22/2000	6/23/2000	9/20/2000	12/13/2000	3/23/2001	6/26/2001	9/19/2001	12/13/2001	3/26/2002	6/12/2002
Upgradient														
MW-4														
Nitrate	2.55	2.55	2.52	2.54	2.19	2.09	2.44	2.47	2.52	3.44	3.78	4.83	5.09	4.04
Ammonia	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	ND
T Nitrogen	3.13	2.55	2.52	2.54	2.19	4.47	2.44	2.47	2.52	3.44	3.78	4.83	5.09	4.04
TKN	0.58	<0.2	<0.2	<0.2	<0.1	2.38	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	ND
Downgradient														
MW-2														
Nitrate	3.85	0.41	2.97	2.84	4.74	2.32	3.12	2.94	3.37	1.20	0.29	3.55	4.25	0.86
Ammonia	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	ND
T Nitrogen	4.07	0.41	3.08	2.84	4.74	2.32	3.12	2.94	3.37	1.20	0.29	3.55	4.25	0.86
TKN	0.22	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	ND
MW-8														
Nitrate	2.90	1.51	2.06	2.18	2.36	3.38	5.23	5.04	4.40	6.37	5.54	4.96	4.50	4.63
Ammonia	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	ND
T Nitrogen	3.55	1.51	2.06	2.18	2.36	3.38	5.23	5.04	4.40	6.37	5.54	4.50	4.50	4.63
TKN	0.65	<0.2	<2	<0.2	<0.2	<0.5	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	ND
MW-11														
Nitrate	2.50	2.58	3.24	2.67	2.89	3.00	3.47	3.44	3.14	3.07	3.18	4.50	4.98	6.46
Ammonia	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	ND
T Nitrogen	2.86	2.58	3.24	2.67	2.89	3.00	3.47	3.44	3.14	3.07	3.18	4.50	4.98	6.46
TKN	0.36	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	ND
MW-11S														
Nitrate	4.05	3.24	3.56	2.59	2.80	3.30	3.31	3.73	3.59	5.39	5.43	4.46	3.72	4.33
Ammonia	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	ND
T Nitrogen	4.92	3.24	3.56	2.59	2.80	3.30	3.31	3.73	3.59	5.39	5.43	4.46	3.72	4.33
TKN	0.87	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	ND
MW-12														
Nitrate	4.45	4.19	4.66	4.90	5.00	6.44	6.73	8.78	8.78	8.94	8.96	12.10	12.00	11.40
Ammonia	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	ND
T Nitrogen	5.03	4.19	4.66	4.90	5.00	6.44	6.73	8.78	8.78	8.94	8.96	12.10	12.00	11.40
TKN	0.58	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	ND

UPGRADIENT AND DOWNGRADIENT WATER QUALITY
(NUTRIENT CONCENTRATIONS)

Monitor Well	9/5/2002	12/5/2002	3/25/2003	6/11/2003	6/11/2003	12/5/2003	3/22/2004	6/15/2004	9/16/2004	12/9/2004	3/29/2005	6/29/2005	9/29/2005	12/23/2005
Upgradient														
MW-4														
Nitrate	4.72	3.08	2.53	3.12	3.04	3.43	2.54	2.33	4.74	2.55	2.74	1.62	2.90	2.90
Ammonia	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.27
T Nitrogen	4.72	3.08	2.53	3.12	3.04	3.43	2.54	2.33	4.74	2.55	2.74	1.62	2.90	3.17
TKN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Downgradient														
MW-2														
Nitrate	1.02	0.85	0.48	0.68	0.74	2.54	1.76	1.51	2.28	3.70	2.93	0.13	0.44	0.49
Ammonia	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.22
T Nitrogen	1.02	0.85	0.48	0.68	0.74	2.54	1.76	1.51	2.28	3.70	2.93	0.13	0.44	0.71
TKN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-8														
Nitrate	4.54	4.24	3.28	3.62	3.59	3.18	2.98	3.13	3.51	3.75	4.47	4.10	4.10	4.00
Ammonia	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
T Nitrogen	4.54	4.24	3.28	3.62	3.59	3.18	2.98	3.13	3.51	3.75	4.47	4.10	4.10	4.00
TKN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-11														
Nitrate	4.47	6.00	4.28	4.78	4.62	4.47	5.08	4.53	4.58	4.95	4.63	4.12	3.90	5.10
Ammonia	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
T Nitrogen	4.47	6.00	4.28	4.78	4.62	4.47	5.08	4.53	4.58	4.95	4.63	4.12	3.90	5.10
TKN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-11S														
Nitrate	4.01	4.28	4.66	4.55	4.44	3.92	4.54	5.04	4.48	4.40	3.73	2.93	3.80	3.80
Ammonia	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.19
T Nitrogen	4.01	4.28	4.66	4.55	4.44	3.92	4.54	5.04	4.48	4.40	3.73	2.93	3.80	3.99
TKN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-12														
Nitrate	10.80	10.70	8.86	8.64	9.61	9.82	8.12	8.14	7.74	7.04	6.98	6.00	6.40	6.50
Ammonia	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
T Nitrogen	10.80	10.70	8.86	8.64	9.61	9.82	8.12	8.14	7.74	7.04	6.98	6.00	6.40	6.50
TKN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Appendix C

UPGRADIENT AND DOWNGRADIENT WATER QUALITY
(NUTRIENT CONCENTRATIONS)

Monitor Well	3/9/2006	6/27/2006	9/7/2006	12/20/2006	3/15/2007	6/15/2007	9/21/2007	12/28/2007	3/27/2008	6/24/2008	9/17/2008	12/15/2008	3/27/2009	6/30/2009
Upgradient														
MW-4														
Nitrate	2.30	1.90	2.10	2.20	1.60	2.80	2.70	3.10	2.70	2.20	3.30	3.30	3.60	3.00
Ammonia	ND	0.45	0.39	0.28	ND	0.11	ND	ND	ND	ND	ND	ND	0.10	0.50
T Nitrogen	2.30	2.35	3.20	2.48	1.60	2.91	2.70	3.10	2.70	2.20	3.30	3.30	3.70	3.90
TKN	ND	ND	1.10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.90
Downgradient														
MW-2														
Nitrate	1.40	0.51	0.25	0.75	1.80	1.20	5.60	1.80	0.28	0.21	0.32	0.98	0.27	0.22
Ammonia	ND	0.20	0.16	0.16	0.14	ND	ND	0.12	ND	ND	ND	ND	ND	ND
T Nitrogen	1.40	0.71	0.92	0.92	1.94	1.20	5.60	1.92	0.28	0.21	0.32	0.98	0.27	0.82
TKN	ND	ND	0.67	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.60
MW-8														
Nitrate	4.20	5.60	5.00	3.80	2.20	3.80	3.40	3.10	3.60	3.40	4.10	3.10	3.90	4.70
Ammonia	ND	0.24	0.17	ND	0.10	0.18	ND	ND	ND	ND	ND	ND	0.10	ND
T Nitrogen	4.20	5.84	7.20	3.80	2.30	3.98	3.40	3.10	3.60	3.40	4.10	3.10	4.00	5.30
TKN	ND	ND	2.20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.60
MW-11														
Nitrate	4.40	7.40	3.90	5.80	4.90	12.00	NT	NT	16.00	11.00	7.70	8.40	5.90	5.70
Ammonia	0.31	0.15	0.13	0.13	0.19	0.26	NT	NT	ND	ND	ND	0.30	0.22	0.30
T Nitrogen	4.71	7.55	4.57	5.93	5.43	12.26	NT	NT	16.00	11.00	7.70	8.70	6.12	6.40
TKN	ND	ND	0.67	ND	0.53	ND	NT	NT	ND	ND	ND	ND	ND	0.70
MW-11S														
Nitrate	3.60	3.50	2.80	2.70	2.10	4.80	4.10	4.90	4.10	3.40	4.40	4.00	3.50	3.40
Ammonia	ND	0.13	0.16	ND	0.19	0.15	ND	ND	0.30	ND	ND	ND	ND	ND
T Nitrogen	3.60	3.63	3.42	2.70	2.29	4.95	4.10	4.90	4.40	3.40	4.40	4.00	3.50	3.90
TKN	ND	ND	0.62	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.50
MW-12														
Nitrate	6.50	7.40	6.90	6.50	3.40	6.70	6.50	5.90	8.00	6.60	7.50	6.80	8.00	7.50
Ammonia	ND	0.45	0.14	0.30	0.28	0.15	ND	ND	ND	ND	ND	ND	ND	ND
T Nitrogen	6.50	7.85	7.50	6.80	3.90	6.85	6.50	5.90	8.00	6.60	7.50	6.80	8.00	7.50
TKN	ND	ND	0.60	ND	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND

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UPGRADIENT AND DOWNGRADIENT WATER QUALITY
(NUTRIENT CONCENTRATIONS)

Monitor Well	9/4/2009	12/14/2009	12/30/2009	3/10/2010	6/23/2010	9/8/2010	12/9/2010	3/29/2011	6/27/2011	9/13/2011	12/14/2011	3/15/2012	6/27/2012	9/12/2012
Upgradient														
MW-4														
Nitrate	3.10	3.50		3.10	2.70	2.70	3.40	3.20	2.80	4.10	3.10	3.50	1.80	3.00
Ammonia	ND	0.44		ND	ND	ND	ND	0.19	ND	ND	ND	0.08	1.79	ND
T Nitrogen	4.90	3.94		3.10	3.30	3.33	3.40	3.39	2.80	4.70	3.10	3.58	6.00	3.00
TKN	1.80	ND		ND	0.60	0.63	ND	ND	ND	0.60	ND	ND	4.20	ND
Downgradient														
MW-2														
Nitrate	0.28	0.51		0.17	0.11	0.26	0.43	0.10	0.18	0.64	0.46	0.42	0.60	0.63
Ammonia	ND	ND		ND	0.17	0.33	0.20	ND	ND	ND	ND	ND	0.16	ND
T Nitrogen	1.78	0.51		0.17	0.28	1.00	0.63	0.10	0.18	1.21	0.46	0.51	0.76	0.63
TKN	1.50	ND		ND	ND	0.74	ND	ND	ND	0.57	ND	ND	ND	ND
MW-8														
Nitrate	4.20	5.20		5.80	6.50	6.50	6.80	9.10	9.50	9.80	8.00	9.70	10.00	10.00
Ammonia	ND	0.33		ND	ND	ND	ND	0.14	ND	ND	ND	ND	0.15	ND
T Nitrogen	5.70	5.53		5.80	6.50	3.70	6.80	9.24	9.50	10.90	8.00	9.70	10.15	10.00
TKN	1.50	ND		ND	ND	ND	ND	ND	ND	1.10	ND	ND	ND	ND
MW-11														
Nitrate	4.90	6.70	6.47	5.70	4.80	3.70	4.20	1.70	4.20	4.70	4.30	4.30	3.80	4.70
Ammonia	ND	0.24	ND	ND	ND	ND	ND	0.59	ND	ND	ND	ND	0.10	ND
T Nitrogen	4.90	11.70	7.31	5.70	4.80	3.70	4.20	2.60	4.71	5.21	4.30	4.30	4.40	4.70
TKN	ND	5.00	0.84	ND	ND	ND	ND	0.90	0.51	0.51	ND	ND	ND	ND
MW-11S														
Nitrate	3.30	4.70		5.00	3.80	3.30	2.90	2.90	3.60	4.50	4.70	5.10	4.30	4.60
Ammonia	ND	ND		ND	0.14	ND	ND	ND	ND	ND	ND	ND	0.10	ND
T Nitrogen	3.30	4.70		5.00	3.94	3.30	2.90	2.90	3.60	4.50	4.70	5.10	4.40	4.60
TKN	ND	ND		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-12														
Nitrate	6.60	8.40		7.60	6.00	5.60	5.90	6.40	5.80	6.20	5.70	6.20	5.30	5.70
Ammonia	ND	ND		ND	ND	ND	ND	ND	ND	ND	ND	ND	0.11	ND
T Nitrogen	6.60	8.40		7.60	6.88	5.60	5.90	6.40	5.80	6.71	6.30	6.20	5.41	5.70
TKN	ND	ND		ND	0.88	ND	ND	ND	ND	0.51	0.60	ND	ND	ND

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UPGRADIENT AND DOWNGRADIENT WATER QUALITY
(NUTRIENT CONCENTRATIONS)

Monitor Well	12/12/2012	3/26/2013	6/18/2013	9/25/2013	12/19/2013	3/20/2014	6/12/2014	9/12/2014	12/10/2014	3/1/2015	6/9/2015	9/17/2015	12/10/2015
Upgradient													
MW-4													
Nitrate	3.50	3.68	3.22	3.95	4.83	4.52	3.59	4.91	2.57	3.06	4.37	4.30	4.20
Ammonia	ND	ND	0.33	0.09	ND	ND	0.18	ND	ND	ND	ND	0.29	ND
T Nitrogen	3.55	4.09	3.72	4.04	5.87	4.52	3.77	4.91	2.57	3.06	4.37	5.50	4.20
TKN	ND	0.41	0.50	ND	1.04	ND	ND	ND	ND	ND	ND	1.20	ND
Downgradient													
MW-2													
Nitrate	1.10	0.36	0.17	0.32	0.89	0.57	0.30	0.73	0.38	0.29	0.22	1.40	1.10
Ammonia	ND	ND	0.15	ND	0.09	ND	0.17	ND	ND	ND	ND	ND	ND
T Nitrogen	1.10	0.36	0.54	0.32	1.55	0.57	0.63	3.19	0.38	0.29	0.22	1.40	1.10
TKN	ND	ND	0.37	ND	0.66	ND	0.33	2.46	ND	ND	ND	ND	ND
MW-8													
Nitrate	11.00	11.40	11.10	12.70	10.10	12.10	10.80	16.40	9.61	21.70	11.70	5.20	8.20
Ammonia	ND	ND	0.09	0.10	ND	ND	0.17	ND	ND	ND	0.09	0.59	0.17
T Nitrogen	11.00	11.40	11.19	12.80	10.10	12.10	10.97	16.40	9.61	21.70	11.79	9.20	9.08
TKN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.00	0.88
MW-11													
Nitrate	4.20	5.32	4.84	5.64	5.41	5.99	4.73	6.97	3.53	7.22	7.63	8.30	7.30
Ammonia	ND	ND	0.13	ND	0.12	ND	0.14	ND	ND	ND	ND	ND	0.14
T Nitrogen	4.63	5.32	4.97	5.64	5.53	5.99	4.87	6.97	3.53	7.22	7.63	8.30	7.44
TKN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-11S													
Nitrate	4.70	6.41	6.39	–	7.81	7.50	5.36	7.32	4.30	7.54	8.88	8.20	8.00
Ammonia	ND	ND	0.18	–	ND	ND	0.17	ND	ND	ND	ND	0.12	0.49
T Nitrogen	4.70	6.41	6.57	–	7.81	7.50	5.53	7.32	4.30	7.54	8.88	8.32	8.49
TKN	ND	ND	ND	–	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-12													
Nitrate	5.80	7.53	7.49	7.10	7.31	7.91	6.55	11.10	6.30	7.47	6.89	8.30	8.00
Ammonia	ND	ND	0.09	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.12
T Nitrogen	5.80	7.53	7.58	7.10	7.31	7.91	6.74	11.10	6.30	7.47	6.89	8.30	8.12
TKN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Eldredge Park Groundwater Data 2014

CERTIFICATE OF ANALYSIS

Barnstable County Health Laboratory (M-MA009)

Report Prepared For:
Sally Desmond
Desmond Well Drilling
P O Box 2783
Orleans, MA 02653

Report Dated: 10/22/2014

Order No.: G1483619

Laboratory ID #: 1483619-01
Sample #:
Collected by: Customer

Description: Water - Drinking Water
Sample Location: Well #2 Eldredge Park Orleans, MA

Collected: 09/25/2014
Received: 09/25/2014

Test Parameters

ITEM	RESULT	UNITS	RL	MCL	METHOD #	TESTED
Turbidity	**0.22**	NTU	0.20		EPA 180.1	9/26/2014
Chlorides	**64**	mg/L	1.0		EPA 300.0	9/25/2014
Nitrate as Nitrogen	**5.4**	mg/L	0.10	10	EPA 300.0	9/25/2014
Sulfate	**13**	mg/L	1.0		EPA 300.0	9/25/2014
Alkalinity	**18**	mg/L as CaCO	2.0		SM 2320 B	9/25/2014
Bicarbonate	**18**	mg/L	2.0		SM 2320 B	9/25/2014
Carbonate	**0.0**	mg/L	2.0		SM 2320 B	9/25/2014
Nitrite as Nitrogen	**ND**	mg/L	0.050	1.0	EPA 300.0	9/25/2014
Total Dissolved Solids	**220**	mg/L	7.0		SM 2540C	9/25/2014
Arsenic	**ND**	mg/L	0.0030	0.010	EPA 200.8	10/20/2014
Beryllium	**ND**	mg/L	0.0030	0.004	EPA 200.8	10/20/2014
Boron	**0.028**	mg/L	0.0051		EPA 200.7	10/1/2014
Cadmium	**ND**	mg/L	0.0030	0.005	EPA 200.8	10/20/2014
Calcium	**9.0**	mg/L	0.10		EPA 200.8	10/20/2014
Chromium	**ND**	mg/L	0.0030	0.1	EPA 200.8	10/20/2014
Copper	**ND**	mg/L	0.0030	1.3	EPA 200.8	10/20/2014
Hardness	**54**	mg/L as CaCO	0.10		SM 2340B	10/20/2014
Iron (total)	**0.18**	mg/L	0.10		EPA 200.8	10/20/2014
Iron, Dissolved	**0.18**	mg/L	0.10		EPA 200.8	10/20/2014
Lead	**ND**	mg/L	0.0030	0.015	EPA 200.8	10/20/2014
Magnesium	**7.8**	mg/L	0.10		EPA 200.8	10/20/2014
Manganese	**0.036**	mg/L	0.0030		EPA 200.8	10/20/2014
Mercury	**ND**	mg/L	0.00030	0.002	EPA 200.8	10/20/2014
Potassium	**2.7**	mg/L	0.10		EPA 200.8	10/20/2014
Selenium	**ND**	mg/L	0.015	0.05	EPA 200.8	10/20/2014
Sodium	**35**	mg/L	0.10	20	EPA 200.8	10/20/2014
Zinc	**ND**	mg/L	0.060		EPA 200.8	10/20/2014
Total Coliform	**Absent**	A/P	0	0	SM 9223	9/25/2014
Conductance	**340**	umohs/cm	2.0		EPA 120.1	9/25/2014
pH	**5.5**	PH AT 25C		6.5-8.5	SM 4500-H-B	9/25/2014

Sodium level is above the maxium contaminant level. Those on a low sodium diet may wish to consult a physician.

ND = None Detected RL = Reporting Limit MCL = Maximum Contaminant Level

CERTIFICATE OF ANALYSIS

Barnstable County Health Laboratory (M-MA009)

Report Prepared For:

Sally Desmond
Desmond Well Drilling
P O Box 2783
Orleans, MA 02653

Report Dated: 10/22/2014

Order No.: G1483619

Attached please find the laboratory certified parameter list.

Approved By: [signature]
(Lab Director)

10/22/2014

ND = None Detected RL = Reporting Limit MCL = Maximum Contaminant Level

CERTIFICATE OF ANALYSIS

Barnstable County Health Laboratory (M-MA009)

Report Prepared For:
Sally Desmond
Desmond Well Drilling
P O Box 2783
Orleans, MA 02653

Report Dated: 10/22/2014

Order No.: G1483618

Laboratory ID #: 1483618-01
Sample #:
Collected by: Customer

Description: Water - Drinking Water
Sample Location: Well #1 Eldredge Park Orleans, MA

Collected: 09/25/2014
Received: 09/25/2014

Test Parameters

ITEM	RESULT	UNITS	RL	MCL	METHOD #	TESTED
Turbidity	0.30	NTU	0.20		EPA 180.1	9/26/2014
Chlorides	46	mg/L	1.0		EPA 300.0	9/25/2014
Nitrate as Nitrogen	5.7	mg/L	0.10	10	EPA 300.0	9/25/2014
Sulfate	14	mg/L	1.0		EPA 300.0	9/25/2014
Alkalinity	16	mg/L as CaCO	2.0		SM 2320 B	9/25/2014
Bicarbonate	18	mg/L	2.0		SM 2320 B	9/25/2014
Carbonate	0.0	mg/L	2.0		SM 2320 B	9/25/2014
Nitrite as Nitrogen	ND	mg/L	0.050	1.0	EPA 300.0	9/25/2014
Total Dissolved Solids	170	mg/L	7.0		SM 2540C	9/25/2014
Arsenic	ND	mg/L	0.0030	0.010	EPA 200.8	10/20/2014
Beryllium	ND	mg/L	0.0030	0.004	EPA 200.8	10/20/2014
Boron	0.023	mg/L	0.0051		EPA 200.7	10/1/2014
Cadmium	ND	mg/L	0.0030	0.005	EPA 200.8	10/20/2014
Calcium	8.1	mg/L	0.10		EPA 200.8	10/20/2014
Chromium	ND	mg/L	0.0030	0.1	EPA 200.8	10/20/2014
Copper	0.0057	mg/L	0.0030	1.3	EPA 200.8	10/20/2014
Hardness	52	mg/L as CaCO	0.10		SM 2340B	10/20/2014
Iron (total)	ND	mg/L	0.10		EPA 200.8	10/20/2014
Iron, Dissolved	ND	mg/L	0.10		EPA 200.8	10/20/2014
Lead	ND	mg/L	0.0030	0.015	EPA 200.8	10/20/2014
Magnesium	7.6	mg/L	0.10		EPA 200.8	10/20/2014
Manganese	0.011	mg/L	0.0030		EPA 200.8	10/20/2014
Mercury	ND	mg/L	0.00030	0.002	EPA 200.8	10/20/2014
Potassium	2.2	mg/L	0.10		EPA 200.8	10/20/2014
Selenium	ND	mg/L	0.015	0.05	EPA 200.8	10/20/2014
Sodium	27	mg/L	0.10	20	EPA 200.8	10/20/2014
Zinc	ND	mg/L	0.060		EPA 200.8	10/20/2014
Total Coliform	Absent	P/A	0	0	SM 9223	9/25/2014
Conductance	270	umohs/cm	2.0		EPA 120.1	9/25/2014
pH	5.5	PH AT 25C		6.5-8.5	SM 4500-H-B	9/25/2014

Sodium level is above the maxium contaminant level. Those on a low sodium diet may wish to consult a physician.

ND = None Detected RL = Reporting Limit MCL = Maximum Contaminant Level

CERTIFICATE OF ANALYSIS

Barnstable County Health Laboratory (M-MA009)

Report Prepared For:

Sally Desmond
Desmond Well Drilling
P O Box 2783
Orleans, MA 02653

Report Dated: 10/22/2014

Order No.: G1483618

Attached please find the laboratory certified parameter list.

Approved By: Benjamin Le
(Lab Director)
10/22/2014

ND = None Detected RL = Reporting Limit MCL = Maximum Contaminant Level

ATTACHMENT M

TECHNICAL MEMORANDUM – FULL-SCALE PERMEABLE REACTIVE BARRIERS WATERSHED PLANNING

AECOM
9 Jonathan Bourne Drive
Pocasset, MA 02559
www.aecom.com

508.833.6950 tel
508.833.6951 fax

Memorandum

To	George Meservey, Director of Planning & Community Development
CC	Betsy Shreve, AICP, AECOM Project Director James Begley, LSP, MT Environmental AECOM PRB Team
Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 12.1.B – NT Demonstration Projects** **Task 12.1.B.2 - Technical Memorandum: Permeable Reactive Barriers (PRB)** **Full-Scale Watershed Planning - Final**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	January 7, 2021

1. Introduction

This Technical Memorandum has been prepared to identify potential full-scale Permeable Reactive Barrier (PRB) locations for implementation in accordance with the overall objectives of the Town of Orleans Amended Comprehensive Wastewater Management Plan (ACWMP). The ACWMP was developed in accordance with the Cape Cod 208 Water Quality Plan, which has been approved by both the United States Environmental Protection Agency (US EPA) and the Massachusetts Department of Environmental Protection (MassDEP).

The ACWMP is a "hybrid" plan that includes provisions for use of conventional wastewater treatment and non-traditional technologies, including PRBs, to remediate nitrate in groundwater. The PRB is a remediation technology that intercepts and removes nitrogen in groundwater at key locations in the watersheds before it discharges to sensitive embayments. Using a non-traditional technology allows for a reduction in sewer collection system coverage and wastewater treatment facility costs while still achieving nitrogen control objectives.

A PRB demonstration project is currently underway at the Eldredge Parkway site at the Nauset Regional Middle School in Orleans. The PRB was implemented in November 2016 and was designed for evaluating of PRB performance. Over the last four years, the project has shown that a PRB is effective in removing nitrate in groundwater. As part of the ACWMP, the Town is planning to install additional PRBs to reduce the nitrate load from nitrate impacted watersheds and estuaries in a cost-effective manner.

Three major watersheds have been identified for PRB groundwater remediation. These include the watersheds to Pleasant Bay, Nauset Estuary and Rock Harbor shown in Figure 1. A planning document Technical Memorandum "Permeable Reactive Barriers Implementation Plan for Full-Scale PRBs" (Implementation Plan) was prepared for the Town of Orleans dated August 6, 2018 and included details on the design and logistics of implementation of full-scale PRBs. The Implementation Plan for full-scale PRBs is in Appendix A and is also available on the Town of Orleans website https://www.town.orleans.ma.us/water-quality-and-wastewater-planning/pages/permeable-reactive-barriers-prb.

2. Orleans Nitrogen Load Reduction Objectives

The watersheds recharging Pleasant Bay, Nauset Estuary and Rock Harbor in Orleans include numerous sub-watersheds that discharge to creeks, rivers and salt ponds as shown in Figure 1. Total Maximum Daily Loads (TMDLs) define the maximum nitrogen load that the water body can receive from all sources, including watersheds, while still meeting necessary water quality criteria. To develop embayment specific TMDLs, the Massachusetts Estuaries Project (MEP) assessed nitrogen loading to the estuaries using an analytical method called the Linked Watershed-Embayment Management Modeling Approach. The model links watershed nitrogen inputs with surface water circulation and nitrogen characteristics to establish nitrogen loading threshold concentrations that must be achieved to restore and maintain water quality standards within the embayments. Exceeding thresholds has significant environmental consequences. For embayments that exceed the TMDL, corrective actions are needed to reduce nitrogen loading to achieve TMDLs in compliance with the federal Clean Water Act and state law.

Threshold nitrogen concentration and TMDLs were developed with results from analysis by MEP documented in technical reports prepared for Pleasant Bay, Rock Harbor and the Nauset Estuary (MEP 2006, MEP 2007, MEP 2012, respectively). The MassDEP and US EPA have approved nitrogen TMDLs for Pleasant Bay. Additional TMDLs are undergoing review by the regulatory agencies. TMDL thresholds and target goals for these estuaries are discussed in more detail below.

A. Pleasant Bay TMDLs

Pleasant Bay is connected to the Atlantic Ocean and is characterized by three main basins including Little Pleasant Bay, Pleasant Bay and Chatham Harbor. The bay has numerous sub-embayments. These sub-embayments are at particular risk of eutrophication from high nitrogen loads entering by direct groundwater discharge and by restricted tidal exchange. The main basins in or adjacent to Orleans include Pleasant Bay Main Basin and Little Pleasant Bay. Sub-embayments in Orleans include Meetinghouse Pond, the Upper and Lower River, Lonnie's Pond (also known as Kescayo Gansett Pond), Namequoit River and Aries Pond, Paw Wah Pond, Quanset Pond, and Pochet Inlet. The estimated nitrate loads to each of the watersheds and sub-watersheds are detailed in the MEP issued report "Massachusetts Estuaries Project Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Pleasant Bay System, Massachusetts" in May 2006.

In June 2017, the Select Boards of Brewster, Chatham, Harwich, and Orleans voted to sign a Resolution of the Towns sharing the Watershed of Pleasant Bay, endorsing the Pleasant Bay Composite Nitrogen Management Analysis as an accurate representation of each Town's share of the current nitrogen load and its responsibility to remove nitrogen in Pleasant Bay (Pleasant Bay Alliance, March 2017). The agreed Town of Orleans share of the Pleasant Bay Watershed nitrogen load is 6,980 kilograms per year (kg/yr) targeting sub-embayments as shown on Table 1.

The Towns also agreed to participate in a Watershed Permit Pilot Project with the Pleasant Bay Alliance, MassDEP, US EPA and the Cape Cod Commission (CCC) to pursue efficiencies and cost savings through coordinated implementation of nutrient management actions. The Pleasant Bay Watershed Permit was issued by MassDEP in August 2018 in accordance with M.G.L. c. 21, § 27(6) and Section 2A of Chapter 259 of the Acts of 2014.

At this time, the Town of Orleans has targeted 100 percent of its share of the nitrogen load to be removed by non-traditional technologies for Lonnie's Pond, Arey's Pond, Lower River, Namequoit River, Paw Wah Pond, Quanset Pond, Pochet, Pleasant Bay Main Basin and Little Pleasant Bay. Other sub-embayment removal goals have smaller targets for non-traditional technologies including 2 percent for Meetinghouse Pond, which will be mainly addressed with conventional wastewater collection and treatment system and 54 percent for the Upper River. Given the expected favorable economic benefits of utilizing non-traditional technologies, the current objective for full-scale PRB selection in this evaluation was to consider all feasible locations within the Pleasant Bay Watershed.

B. Nauset Harbor Embayment System TMDLs

The Nauset Harbor Embayment System in Orleans and Eastham is connected to the Atlantic Ocean and is comprised of open waters including Nauset Harbor, Town Cove, Nauset Marsh (located behind Nauset Barrier Beach) and three sub-embayments: Salt Pond, Wood Cove and Mill Pond. The Nauset Harbor Estuary watershed is shared by the Towns of Orleans, Eastham and Brewster. The most impacted areas with impaired habitat and therefore the focus of nitrogen load reduction in Orleans, include the upper reach at Town Cove and the semi-enclosed Mill Pond and Wood Cove sub-embayments. The Salt Pond sub-embayment in Eastham is also at risk of eutrophication. MEP issued the report "Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Nauset Harbor Embayment System, Towns of Orleans and Eastham, Massachusetts" in 2012 to support TMDLS for the estuary.

The Nauset Embayment System exceeds the MEP established TMDL requiring measures to lower the combined watershed nitrate load to the estuary (Howes et. al., 2012). The Town Cove nitrate TMDL is 21,432 kg/yr with a Target Threshold Watershed Load (comprised of natural background, fertilizer, runoff and septic system loads) of 4,368 kg/yr. According to the MEP report, the existing Watershed Load is 11,532 kg/yr. Therefore, a reduction of 7,164 kg/yr of nitrogen load is necessary to restore and maintain the Town Cove's water quality below the Target Threshold Load. Orleans has identified a PRB technology removal target or goal of 566 kg/yr for Town Cove. The objective for full-scale PRB selection in this evaluation was to consider all feasible locations within the Nauset Watershed.

C. Rock Harbor Embayment System TMDLs

The Rock Harbor Embayment System is in the Towns of Orleans and Eastham. Rock Harbor is a man-made harbor at the mouth of a tidal river and salt marsh and opens to Cape Cod Bay to the north. Significant habitat quality impairment and the presence of algal mats have been observed in the lower reach harbor area, while the upper reach marsh area has a higher quality habitat. MEP issued the report "Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Rock Harbor Embayment System, Towns of Orleans, Massachusetts" in December 2008 to support TMDLs for the estuary. The Rock Harbor System total TMDL 1,827 kg/yr with at Target Threshold Watershed Load of 1,358. The Present Watershed Load, comprised of natural background, fertilizer, runoff, WWTF and septic system loads, is 3,309 kg/yr, leaving 1,951 kg/yr to be removed. The Orleans' PRB technology removal target for nitrate is 634 kg/yr. The objective in this evaluation was to consider all possible locations within the Rock Harbor Watershed.

3. Site Selection Process

The PRB site selection process documented in this technical memorandum has identified 14 potential PRB locations within the sub-watersheds to Pleasant Bay, 3 PRB locations in the Nauset watershed and 1 location within the Rock Harbor watershed. PRBs were identified using local roadway names. Location and physical characteristics of the potential PRBs are included in Table 2 and shown on Figure 2.

A variety of information sources were used to support the PRB selection process. Land use was reviewed in the Orleans Geographic Information System https://www.town.orleans.ma.us/planning-department/pages/gis-mapping. Hydrogeologic information including groundwater flow and watershed delineations were gathered from MEP reports and from the regional USGS Monomoy Lens groundwater model (Walter and Whealan, 2005). Additional groundwater data were obtained from a 1990s CCC investigation of soils, water level and water quality data across the Town of Orleans. The CCC gathered soil boring and water level data from numerous previous investigations and installed additional soil borings and monitoring wells to evaluate soil and groundwater elevations throughout Orleans. These data were summarized in a report titled "Orleans Water Table Mapping Project, Orleans Massachusetts", dated May 1995.

Full scale PRB location screening considered overall nitrogen remediation objectives, environmental conditions, land use, downgradient water use, topography, wastewater nitrogen load upgradient within the capture zone of the PRB and practical limitations to cost effective implementation of the technology.

4. PRB Characteristics and Initial Siting Criteria

Initial PRB siting criteria were used to assess potential full-scale PRB locations in each of the three major watersheds. Criteria included:

- Locating PRBs along roadways that are cross-gradient to the regional groundwater flow direction and within a watershed requiring long term groundwater remediation;
- The depth to groundwater, generally less than 40 feet (depth affects costs and may affect feasibility);
- The accessibility of the PRB for installation, upgradient and downgradient monitoring well installation, and long-term monitoring; and
- The location where groundwater discharges to the most sensitive upper reaches of the estuary where possible.

A PRB screening matrix was developed to identify relevant characteristics and record results of assessments of effectiveness discussed below. Candidate locations were mapped, depth to groundwater was estimated based on topography and groundwater elevation contours and the vertical extent of the PRB was defined. Screening included evaluation of roadway orientation upgradient of target embayments, considering sub-watersheds to determine PRB location and PRB total length. The road layout and land use assessment utilizing the Orleans Geographic Information System (GIS) database was followed up with field surveys.

5. Detailed Analysis of PRB Effectiveness

Potential PRB locations identified in the initial screening were assessed for effectiveness of nitrogen mass removal by evaluating:

- The dimensions of the proposed PRB;
- Groundwater flow direction;
- The density of wastewater nitrogen sources upgradient of and within the capture zone of the PRB; and
- The ability in aggregate to achieve PRB nitrate mass remediation goals given the current assumptions.

The density of septic system wastewater nitrogen sources was assessed by estimating the number of parcels within the capture zone or area of groundwater intercepted by the PRB and then calculating the nitrogen load generated in that area with specified assumptions. A feasible PRB installation depth of approximately 70 to 80 feet below ground surface was assumed. This depth limitation and the depth to groundwater affects the size of the upgradient capture zone of a PRB. The upgradient area of groundwater that will flow through the PRB is limited because groundwater generally flows deeper into the aquifer as it moves towards the receiving water. Once it reaches the receiving water body groundwater moves up to discharge. At a certain distance upgradient, groundwater originating further upgradient will flow under the PRB and groundwater from that area cannot be treated by the PRB.

AECOM developed a groundwater flow model for the Town of Orleans based on the USGS, Sagamore and Monomoy flow lens Model (Walter and Whealan 2005). This model has been previously used to evaluate groundwater mounding and alterations to groundwater flow paths resulting from the proposed WWTF Groundwater Discharge at 32 Lots Hollow Road and 43 Lots Hollow Road in Orleans (AECOM, 2018). The model is also suitable for evaluating the area contributing groundwater to the proposed PRBs. The capture zone area was estimated by using the model to backtrack particles, simulating a drop of water's flow path, upgradient of each PRB. This was accomplished by using MODPATH (Pollock, 1994) in conjunction with the MODFLOW (McDonald and Harbaugh, 1988) software.

The wastewater load within the defined capture zone was then estimated by counting parcels within the capture zone and assigning an annual nitrogen load for the PRB. This estimate considers wastewater related nitrogen only and does not account for fertilizer applied to the land and atmospheric deposition of nitrogen within the capture zone. The wastewater load estimate assumed one house per parcel. The parcel nitrate load assigned was based on a reference wastewater nitrogen concentration of 26.25 mg/L used in MEP studies and a town-wide average water use of 150 gallons per day per parcel based on Orleans water records for 2014 and 2015. The estimated annual nitrogen load generated per parcel was 5.44 kg/yr.

Nitrogen from fertilizer, atmospheric deposition, and the presence of multi-unit condominiums on one parcel would increase the estimated nitrogen load in the capture zone. MassDEP has indicated a preference for use of actual nitrogen flux data and PRB nitrogen removal performance for determining the nitrogen load removal credit assigned to PRBs. However, the MEP based estimate of 5.44 kg/yr has been used as a surrogate in this evaluation. Ultimately PRB performance will be measured by actual groundwater nitrogen load and PRB reduction as determined through groundwater monitoring.

Prior to assigning a nitrate load to each parcel, the parcels were reviewed for land use type and mapped conservation land and parcels without obvious development were not counted. The parcel count is included in Table 3. PRB lines, particle backtracks, and highlighted parcels show the capture zones and counted parcels on Figure 2. For the purposes of site selection screening, the assumed nitrogen load removal by PRBs is 80 percent of the wastewater load generated within the capture zone. Current monitoring of the Eldredge Parkway Demonstration PRB indicates a greater than 80 percent nitrogen removal efficiency. However, it is anticipated that an 80 percent efficiency will be selected as the target for PRB management over time, triggering replenishment of PRB carbon source once average efficiency drops below 80 percent.

The estimated annual nitrogen load in the capture zone of each PRB was normalized to PRB length to assess load reduction on a kilogram per linear foot per year (Kg/LF/yr) basis for comparison with other potential PRBs. The estimated PRB efficiency considering all locations ranged from 0.09 to 0.40 Kg/LF/yr. PRBs in each major watershed were ranked for efficiency and given a rank as shown in Table 3.

The calculated efficiency was supplemented with a qualitative evaluation of PRB location relative to the most impacted sub-embayments based on MEP modeled total nitrogen concentrations and embayment specific non-traditional technology goals to guide potential funding and implementation planning.

6. Implementation Cost

AECOM has estimated the implementation cost for each PRB installation based on $1,230.00 per linear foot of PRB line. This cost includes:

- Town administration;
- Engineering design;
- Monitoring well installation and baseline sampling;
- Injection contractor and sub-state costs; and
- Engineering oversight of implementation.

PRB implementation costs range from $492,000 for a 400-foot PRB to $8,979,000 for a 7,300-foot PRB as shown in Table 4. Additional future costs will include long term monitoring, replacement costs for any damaged monitoring wells and subsequent substrate injection events. These costs were developed for the Wastewater Infrastructure Long Term Financial Plan that will address a phased implementation schedule for selected PRBs over a 10-year period.

7. Life Cycle Cost Analysis

A Life Cycle Cost Analysis (LCCA) was performed to compare PRBs and Traditional Systems. The purpose of this LCCA was to estimate the overall costs of PRBs and Traditional Systems and to utilize the information to assist the Town in selecting the alternative which will provide the lowest overall cost (implementation plus operation and maintenance) based on a cost per kg nitrate removed.

For both the PRBs and Traditional Systems, numerous costs associated with implementation (e.g. planning, design, bidding, construction, etc.) plus operation and maintenance of each the alternative was estimated. The following summarizes the unit costs utilized for the LCCA.

PRBs

Description	Unit Cost
Implementation Cost [1] ($/LF)	$1,230
Replacement Cost [2] ($/LF Annual basis)	$63
Monitoring Cost [3] ($/LF)	$17

Notes:

1. Unit costs developed based on the Eldredge Park Way PRB Demonstration Project.
2. Replacement costs will occur every 15 years for PRB reinjection.
3. Monitoring costs represent an average on $/LF basis. This may vary by location due to reporting efforts and costs.

Traditional Systems

Description	Unit Cost
Collection System and Pumping Stations	
Gravity Sewer (lf)	$425
Low-Pressure Sewer (lf)	$200
Pumping Station (each)	$1,500,000
Force Main (lf)	$200
Highway Crossing (l.s.)	$500,000
O&M Cost ($/gal)	$1.75
WWTF and Aquifer Recharge	
WWTF ($/gal)	$100
Force Main (lf)	$200
Effluent Disposal ($/gal)	$10
O&M Cost ($/gal)	$3.25

Notes:

1. Based on the Average of Bids Received on May 6, 2020 for Contract 2019-02 - Downtown Area Collection System and Pumping Stations
2. O&M Cost Based on Estimated O&M Cost for Contract 2019-02 - Downtown Area Collection System and Pumping Stations
3. Based on the Average of Bids Received on May 13, 2020 for Contract 2019-01 - Downtown Area WWTF and Effluent Disposal
4. O&M Cost Based on Estimated O&M Cost for Contract 2019-01 - Downtown Area WWTF and Effluent Disposal

The LCCA utilized the following assumptions:

Factors	N Removal
Term at 30, 60 and 100 Years	Utilized 26.25 mg/l per MEP Studies
Interest Rate at 1.5%	PRBs - 80% Removal from Watershed
Inflation at 3.0%	Traditional System - 100% Removal from Watershed

The PRB LCCA costs (on a cost per kg nitrate removed basis) were than compared to the Traditional System LCCA costs (on a cost per kg nitrate removed basis). Conclusions are as follows:

1. When compared to Traditional Systems approximately:
    a. 80 percent of the proposed PRBs are more cost effective (on a cost per kg nitrate removed basis) over a 30-year life-cycle cost analysis; and
    b. 27 percent of the proposed PRBs are more cost effective (on a cost per kg nitrate removed basis) over a 100-year life-cycle cost analysis.
2. The proposed PRBs at Granny's, Richwood, Blossom and Norseman are more cost effective (on a cost per kg nitrate removed basis) compared to the Traditional Systems based on the 30-year, 60-year and 100-year life-cycle costs.
3. The proposed PRBs at Winslow, Gosnold and Rock Harbor are not as cost effective (on a cost per kg nitrate removed basis) as compared to the Traditional Systems based on the 30-year, 60-year and 100-year life-cycle costs.

Refer to the following summary; Table 4 for the 30-year, 60-year and 100-year life-cycle cost analysis for PRBs; and Table 5 for the 30-year, 60-year and 100-year life-cycle cost analysis for Traditional Systems.

Comparison of PRBs and Tranditional Systems on a Cost per kg Nitrate Removed Basis						
PRB Description	LCCA at 30 Years		LCCA at 60 Years		LCCA at 100 Years	
	PRBs	Traditional System	PRBs	Traditional System	PRBs	Traditional System
Pleasant Bay Estuary						
Monument	X			X		X
Keziah's	X			X		X
Mayflower	X		X			X
Namequoit, Ridge & Lockwood	X		X			X
Quonset 1, 2, & 3	X		X			X
Granny's	X		X		X	
Winslow		X		X		X
Richwood	X		X		X	
Duck Hole	X			X		X
Gosnold		X		X		X
Briar Spring	X			X		X
Blossom	X		X		X	
Nauset Estuary						
Tonset Road and Main Street	X			X		X
Norseman	X		X		X	
Rock Harbor Estuary						
Rock Harbor		X		X		X
Totals	12	3	7	8	4	11

8. Consideration of Current Groundwater Use for Water Supply

Groundwater is currently used for water supply throughout the Town of Orleans. The Town operates municipal wells and has a water main distribution system servicing much of the Town. Private potable water supply wells are scattered throughout the Town with concentrations of these wells in certain areas. Parcels with private wells are shown on Figure 2. PRBs were only considered at locations downgradient of zones of contribution to municipal wells. AECOM assessed the distribution of private wells through town records and identified several potential private wells and parcels with potential private wells downgradient of PRBs. Parcels with private wells near potential PRBs appear to also be located adjacent to town municipal water mains and will need to be connected to town water to avoid any potential secondary water quality effects to potable water and to facilitate permitting PRB injection through the Massachusetts Underground Injection Control Program.

9. Conclusions

The performance of PRBs was considered against specific nitrogen reduction goals for non-traditional technologies. In certain watersheds, such as the watersheds to Town Cove and Meetinghouse Pond, traditional wastewater treatment will provide most of the nitrogen load reduction necessary to achieve TMDLs. Enhanced aquaculture will be also be pursued as an additional non-traditional technology but will not be assigned a specific share of the non-traditional remediation goal for watershed permitting in current planning.

The PRB siting criteria that specifies locating PRBs along roadways that are cross-gradient to the regional groundwater flow direction is important for access and feasible installation. However, this criterion also significantly limits the locations that can be selected. This limitation is considered the single most restrictive criterium for placement of PRBs, affecting PRB options and achievement of nitrogen remediation goals. Areas with significant concentrations of private wells were also avoided in locating PRBs due to concern for potential impacts to drinking water quality. A modified approach to PRB installation may be necessary to select additional locations or other alternatives may be necessary to achieve remediation goals. The ability of PRBs to achieve specific watershed goals are discussed in more detail below.

A. Pleasant Bay PRBs

A total of fourteen PRBs were identified in the Pleasant Bay Watershed. PRBs were placed in targeted sub-watersheds to the extent possible. Nitrogen removal requirements for sub-embayments are presented in Table 1. Nitrogen remediation requirements for Quanset Pond were included with Pleasant Bay/Little Pleasant Bay in this analysis due to difficulties in addressing Quanset Pond directly, giving a total of nine remediation goals used for comparison to estimate nitrogen load reductions. Measures of PRB effectiveness in relation to remediation goals are presented in Table 3 including:

- Estimated sewer load reduced (kg/yr) at 80% PRB efficiency;
- Percentage of embayment non-traditional technology goal achieved; and
- Estimated PRB efficiency (kg/LF/yr).

The nine targeted sub-watersheds cannot be fully remediated with PRBs to exceed the required non-traditional technology targets with the given assumptions. The overall projected PRB nitrogen reduction for Pleasant Bay based on the given assumptions was 2,115 kg/yr which is less than half the total Pleasant Bay non-traditional technology remediation goal of 4,966 kg/yr. However, the proposed PRBs could remove a significant percentage, ranging from 29 percent to 70 percent of the required removal load to impacted sub-watersheds.

The most efficient PRB in the Pleasant Bay watershed on a kilograms-of-nitrogen removed per linear foot per year basis was the Ridge (Ridgewood Road) PRB with a nitrogen removal efficiency of 0.27 Kg/LF/yr. In combination, the Ridge PRB and the Namequoit (Namequoit Road) PRB achieved an estimated 70 percent reduction in targeted nitrogen load to the Namequoit River. The Namequoit River is also an upper reach priority embayment that is significantly impacted by nitrogen load. Nitrogen load reduction in upper reaches of the estuary is a priority because upper reaches are the most impacted and nitrogen reduction in upper reaches will also benefit all lower areas in the estuary closer to the inlet to the bay.

Four PRB locations were identified in the Pochet Neck Stream and Pochet watersheds which is also a priority upper reach of the estuary with significant impact from nitrogen load. In combination these PRBs would remove 48 percent of the 1,564 kilograms of nitrogen load targeted for Pochet.

PRB locations could not be identified for Arey's Pond mainly due to roadway orientation and developed parcel locations. Meetinghouse Pond watershed will be remediated with conventional wastewater treatment and no PRB were located in the Meetinghouse Pond sub-watershed.

B. Nauset Estuary PRBs

Three potential PRBs were identified for the Nauset Estuary with a total projected nitrogen remediation of 866 kg/yr, which significantly exceeds the non-traditional technology goal of 566 kg/yr for Town Cove. The Tonset PRB was the largest identified and could be considered to help achieve the 7,164 kg/yr of nitrogen load reduction necessary to restore and maintain the Town Cove's water quality on an interim basis, treating existing load already in the groundwater while traditional wastewater systems are brought online. The relatively small 750-foot-long Main Street PRB was projected to be very efficient with a nitrogen removal of 0.4 Kg/LF/yr while the much longer Tonset PRB had a significantly lower nitrogen removal efficiency of 0.06 Kg/LF/yr.

C. Rock Harbor PRBs

One PRB location was identified for Rock Harbor along Rock Harbor Road that is estimated to remove 305 kg/yr of nitrogen which is less than half the Rock Harbor non-traditional remediation goal of 634 kg/yr. The Rock Harbor PRB had a relatively low nitrogen removal efficiency of 0.08 kg/LF/yr.

The results of the effort to identify potential full-scale PRB locations indicated there are many viable options for PRBs. Preliminary analysis indicates some locations are clearly more efficient and cost effective than others. PRBs identified in this process do not fully achieve nitrogen remediation goals for non-traditional technologies and additional alternatives may be required. The identified PRBs do however provide an important starting point for implementation of non-traditional technologies and are expected to provide for significant nitrogen removal. Actual groundwater data from field investigations will be necessary to confirm expected PRB performance in relation to remediation goals and may indicate higher effectiveness by accounting for additional nitrogen sources and/or higher source strength than considered in the screening assumptions. Groundwater data and a calculated mass flux of nitrogen is the MassDEP's preferred method for assessing PRB performance. The field data collected from monitoring wells will be used to assess the actual mass of nitrogen intercepted by the PRB on an annual basis.

Each of the potential PRB locations were evaluated based on the following considerations:

- Estimated PRB Efficiency (kg/LF/yr)
- Ability to meet PRB Non-traditional technology goal (kg/yr)
- Life Cycle Cost Analysis (PRBs vs Traditional System)
- Secondary Water Impacts (Public and Private Water Supplies: Existing and Future)
- Location of PRBs vs. Wastewater Service Areas
- PRB location with regards to embayment
- Watershed Compliance (N Reduction)
- Environmental Response (Short Term vs. Long Term)
- Implementation Costs (Capital Improvement Plan)

Critical factors include the estimated PRB efficiency (Kg/LF/yr), location, and ability to contribute to remedial goals (percent nitrogen reduction). Even PRBs with relatively low efficiency can be beneficial if sufficient length can be installed to achieve significant nitrogen reduction (% N reduction). In some cases, short length PRBs with high efficiency but low % N reduction can be worthwhile and are cost effective. In addition, PRB location with respect to the upper reach or head of the estuary matters. The upper reaches are the most impacted by eutrophication from nitrogen loading, with documented overload of nutrients. Reducing nitrogen loading in the upper estuary improves water quality throughout the bay. The following table presents the results of the evaluation as well as identifies as to whether the location is feasible for PRB implementation.

Embayment	PRB Name	Remarks	Feasible PRB Location (Y / N)
Pleasant Bay Estuary (Orleans)			
Meetinghouse Pond	None	N/A Conventional treatment	N/A
Lonnies Pond / Kescayo Gansett River	Monument	• High priority upper reach • Higher efficiency • Significant % N reduction	Y
Aery's Pond	None	Fails to meet siting criteria	N
Upper River	Keziahs	• High priority upper reach • Moderate efficiency • Significant % N reduction	Y
Lower River	Mayflower	• High priority upper reach • Moderate efficiency • Low % N reduction	Y
Namequoit River	Namequoit	• High priority upper reach • Higher efficiency • Highest % N reduction	Y
	Ridge	• High priority upper reach • Highest efficiency • Highest % N reduction	Y
Pah Wah Pond	Lockwood	• High priority upper reach • Moderate efficiency • Lower % N reduction	Y
Quanset and Pleasant Bay Main Basin	Quonset 1,2,3	• High priority upper reach • Moderate efficiency • Significant % N reduction	Y
	Grannys	• Lower priority location • Higher efficiency • Moderate % N reduction	Y
	Winslow	• Lower priority location • Low efficiency • Low % N reduction	N

Embayment	PRB Name	Remarks	Feasible PRB Location (Y / N)
Pochet	Richwood	• Lower priority location • Higher efficiency • Significant % N reduction	Y
	Duck Hole	• High priority upper reach • Lower efficiency • Significant % N reduction	Y
	Gosnold	• High priority upper reach • Low efficiency • Moderate % N reduction	Y
	Briar Spring	• High priority upper reach • Moderate efficiency • Significant % N reduction	Y
	Blossom	• High priority upper reach • Higher efficiency • Low % N reduction	Y
Nauset Estuary (Orleans)			
Town Cove	Tonset	• High priority upper reach • Low efficiency • High % reduction	Y
	Main	• High priority upper reach • High efficiency • High % reduction	Y
Mill Pond	Norseman	• Lower priority location • Higher efficiency • Significant % reduction	Y
Rock Harbor Estuary (Orleans)			
Rock Harbor	Rock Harbor	• High priority upper reach • Lower efficiency • Significant % reduction	Y

Not all feasible PRBs are recommended for implementation and some of the feasible PRBs are less beneficial than others and should be installed after the more advantageous locations. The Rock Harbor PRB and the Nauset Watershed Tonset PRB are in areas adjacent to planned conventional wastewater treatment service areas and would be better served by extending the conventional system. The Rock Harbor and Tonset PRBs are therefore not recommended for additional investigation. The potential Winslow PRB in the Pleasant Bay Watershed does not rank high enough to be considered for implementation due to projected low efficiency and low nitrogen removal, in addition to being in an area that does not affect the upper reaches or a confined sub-embayment of Pleasant Bay.

Implementation of the remaining feasible PRBs in the watersheds to Nauset Estuary and Pleasant Bay should move forward. In Nauset Estuary the recommended PRBs include the Main Street PRB adjacent to Town Cove, a relatively short cost effective PRB at a location that could provide a significant short-term benefit prior to the water quality improvements resulting from the Downtown conventional system. If implemented this PRB could address nitrogen already released to groundwater and migrating to Town Cove over the next 20 years. The Norseman PRB is also a relatively short PRB that is cost effective and would improve water quality in the Mill Pond sub-embayment. These locations should be investigated as described in the Next Steps presented below.

The remaining 13 PRBs in the Pleasant Bay Watershed should also move forward in the process and be investigated to confirm hydrogeologic conditions and water quality. A priority for implementation should be established based on the additional information and consideration of efficiency and nitrogen reduction potential.

10. Next Steps

Additional effort is necessary to confirm potential PRB locations and plan the appropriate sequencing of PRB implementation. Additional criteria for final selection of PRB locations will include site specific investigations and evaluations as follows:

A. Continue PRB Watershed Planning in order to reduce nitrogen based on the results of the Eldredge Park PRB Demonstration Test and previous Watershed Planning Activities. Conduct (a) field investigations; (b) subsurface investigations; and (c) sampling, analysis and evaluation on the following:

- Two potential PRB locations in the Nauset Estuary
  - ✓ Main Street
  - ✓ Norseman
- Thirteen potential PRB locations in the Pleasant Bay Estuary
  - ✓ Blossom
  - ✓ Briar Spring
  - ✓ Duck Hole
  - ✓ Gosnold
  - ✓ Grannys
  - ✓ Keziahs
  - ✓ Lockwood
  - ✓ Mayflower
  - ✓ Monument
  - ✓ Namequoit
  - ✓ Quonset 1,2,3
  - ✓ Richwood
  - ✓ Ridge

B. Field Investigations

- Perform field investigations to confirm suitability of the proposed PRB locations along roadways; types of utilities present; roadway ownership; accessibility for upgradient and downgradient monitoring well installation and long-term monitoring; and potential environmental impacts.
- Based on Board of Health information, verify the location and status of any private wells located in the vicinity of the proposed PRBs.
- Field investigations to occur on up to ten PRB locations.

C. Subsurface Investigations

- Perform subsurface investigations to obtain subsurface geologic condition and to confirm groundwater flow directions and water quality.
- Subsurface investigations to occur as follows:
  - ✓ Part 1 – Conduct drilling operations with soil sampling, groundwater profiling, and groundwater monitoring well installation and sampling at up to three locations at each potential PRB site. Based on the information obtain, evaluate the feasibility of each location as a potential PRB location and conduct additional subsurface investigations at sites which are deemed feasible.
  - ✓ Part 2 – Conduct drilling operations with soil sampling, groundwater profiling, and groundwater monitoring well installation and sampling at up to five additional locations at each potential PRB site identified as feasible.

D. Sampling, Analysis and Evaluation

- Obtain hydrogeologic information and results of groundwater analyses and conduct an evaluation to develop a baseline nitrogen concentration profile, geologic and geochemistry data to support a cost-effective implementation.
- Sampling and evaluation to occur on up to eight monitoring well locations at each PRB.

E. Regulatory and Local Coordination

- Coordinate with the MassDEP, the Town of Orleans and the Pleasant Bay Alliance to discuss planning activities, the results of the investigations and the evaluation of the proposed PRB site. Setup and participate in up to two meetings.
- Update the Town's webpage to include documents and presentations prepared as part of this phase of the project.

F. Update the Full-Scale Watershed Planning Report – Update the Full-Scale Watershed Planning Report to incorporate the planning activities, the results of the investigations and the evaluation of the proposed PRB sites.

G. Meetings

- Prepare for and conduct two public meetings with the Select Board, Board of Water and Sewer Commissioners, Planning Department and the public at large to obtain stakeholder input;
- Prepare for and conduct four coordination meetings Board of Water and Sewer Commissioners, Planning Department and Department of Public Works and Natural Resources the public at large to obtain stakeholder input.

This Technical Memorandum provides information for review by public stakeholders to facilitate ongoing public involvement in the process. Prior to final selection, location-specific assessment are necessary to confirm existing conditions and the nature of hydrogeological conditions and groundwater chemistry to estimate nitrogen flux at PRB locations.

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Tables

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Table 1
Orleans PRB Selection Matrix

Pleasant Bay Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	Length (ft)	Roads	Saturated Depth (ft)	Depth Range to GW (ft)	Estimated Parcels	Estimated Sewer Load reduced (kg/yr) at 80% PRB Efficiency	Embayment Non-Traditional Technology Goal (kg/yr)	Estimated kg/LF/yr	Pleasant Bay Watershed PRB kg/yr Efficincy Rank	PRB Installation Cost Estimate	30-year LCCA for PRB (Present Worth)	Evaluation Notes
Meeting House Pond	None						**0**	**0**	**40**					
Lonnies Pond/Kescayo Gansett River							**41**	**178**	**284**					
Lonnies Pond/Kescayo Gansett River	Monument	25, 26 Lonnies Pond/Kescayo Gansett River	1,675	Monument	30	25 to 50	41	178		0.11	**8**	$2,060,250	$4,889,900	Upper Reach Priority embayment
Aerys Pond	None						**0**	**0**	**113**					
Upper River							**26**	**113**	**202**					
Upper River	Keziahs	41 Upper River	1,250	Keziahs	30	15 to 40	26	113		0.09	**9**	$1,537,500	$3,775,700	Upper Reach Priority embayment
Lower River							**35**	**152**	**517**					
Lower River	Mayflower	28 Lower River	1,700	Pershing, Kenneth	30	10 to 30	35	152		0.09	**11**	$2,091,000	$4,969,200	
Namequoit River							**56**	**244**	**348**					
Namequoit River	Namequoit	30 Namequoit River	1,000	Namequoit Road	30	10 to 40	27	117		0.12	**6**	$1,230,000	$7,577,200	Upper Reach Priority embayment
Namequoit River	Ridge	30 Namequoit River	460	Ridgewood Rd	30	10 to 30	29	126		0.27	**1**	$565,800	d with Namequoit PRB	Upper Reach Priority embayment
Pah Wah Pond							**35**	**152**	**413**					
Pah Wah Pond	Lockwood	32 Pah Wah Pond	1,230	Lockwood	30	5 to 15	35	152		0.12	**5**	$1,512,900	d with Namequoit PRB	Upper Reach Priority embayment
Quanset and Pleasant Bay Main Basin							**122**	**531**	**1485**					
Quanset and Pleasant Bay Main Basin	Quonset 1,2,3	33, 37 Pleasant Bay and Quanset Pond	1,745	Towhee, Lake Dr, Oyster	30	10 to 40	43	187		0.11	**7**	$2,146,350	$5,071,900	Upper Reach Priority embayment
Quanset and Pleasant Bay Main Basin	Grannys	33, 37 Pleasant Bay and Quanset Pond	650	Grannys Ln	30	15 to 20	24	104		0.16	**4**	$799,500	$2,174,200	Upper Reach Priority embayment
Quanset and Pleasant Bay Main Basin	Winslow	33, 37 Pleasant Bay and Quanset Pond	1,150	Winslow Dr and Way	30	5 to 40	14	61		0.05	**14**	$1,414,500	$3,496,900	Upper Reach Priority embayment
Quanset and Pleasant Bay Main Basin	Richwood	33, 37 Pleasant Bay and Quanset Pond	890	Richwood Farm	30	10 to 15	41	178		0.20	**2**	$1,094,700	$2,805,100	Upper Reach Priority embayment
Pochet							**171**	**744**	**1,564**					
Pochet	Duck Hole	35 Pochet Neck Stream	4,100	High View, Old Duck Hole, Lovell	30	5 to 35	68	296		0.07	**12**	$5,043,000	$11,335,800	Upper Reach Priority embayment
Pochet	Gosnold	34, 35 Pochet and Pochet Neck Stream	2,081	Gosnold,	30	10 to 30	29	126		0.06	**13**	$2,559,630	$5,966,700	Upper Reach Priority embayment
Pochet	Briar Spring	34 Pochet	2,906	Briar Spring	30	10 to 35	59	257		0.09	**10**	$3,574,380	$8,168,400	Upper Reach Priority embayment
Pochet	Blossom	35 Pochet	400	Blossom , Sparrowhawk	30	30 to 40	15	65		0.16	**3**	$492,000	$1,513,400	Upper Reach Priority embayment
Pleasant Bay Estuary (Orleans)			**21,237**				**486**	**2,115**	**4,966**			**$26,121,510**	**$61,744,400**	
	Average Efficiency kg/LF/yr									**0.10**				

Nauset Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	Length (ft)	Roads	Saturated Depth (ft)	Depth Range to GW (ft)	Estimated Parcels	Estimated Sewer Load reduced (kg/yr) at 80% PRB Efficiency	Embayment Non-Traditional Technology Goal (kg/yr)	Estimated kg/LF/yr	Pleasant Bay Watershed PRB kg/yr Efficincy Rank	PRB Installation Cost Estimate	30-year LCCA for PRB (Present Worth)	Evaluation Notes
Town Cove							**171**	**744**	**566**					
Town Cove	Tonset	5 Town Cove	7,300	Gibson, Tonset	30	10 to 30	93	405		0.06	**3**	$8,979,000	$22,059,000	Upper Reach Priority embayment
Town Cove	Main	5 Town Cove	850	Main	40	5 to 10	78	339		0.40	**2**	$1,045,500	luded with Tonset PRB	Upper Reach Priority embayment
Mill Pond							**28**	**122**						
Mill Pond	Norseman	8 Mill Pond	580	Norsemans Road, Mill Pond Rd	40	10 to 35	28	122		0.21	**1**	$713,400	$1,999,700	Upper Reach Priority embayment
Nauset Estuary (Orleans)			**8,730**				**199**	**866**				**$10,737,900**	**$24,058,700**	
	Average Efficiency kg/LF/yr									**0.22**				

Rock Harbor Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	Length (ft)	Roads	Saturated Depth (ft)	Depth Range to GW (ft)	Estimated Parcels	Estimated Sewer Load reduced (kg/yr) at 80% PRB Efficiency	Embayment Non-Traditional Technology Goal (kg/yr)	Estimated kg/LF/yr	Pleasant Bay Watershed PRB kg/yr Efficincy Rank	PRB Installation Cost Estimate	30-year LCCA for PRB (Present Worth)	Evaluation Notes
Rock Harbor Main	**Rock Harbor**						**70**	**305**	**634**					
Rock Harbor	Rock Harbor	3 Rock Harbor Main	3,940	Rock Harbor	50	5 to 15	70	305		0.08	1	$103,425	$10,896,700	Upper Reach Priority embayment
Rock Harbor Estuary (Orleans)	**Rock Harbor**		**3,940**				**70**	**305**	**634**	**0.08**		**$4,846,200**	**$10,896,700**	

PRB Townwide Potential Total			**33,907**				**755**	**3,286**				**$41,705,610**	**$96,699,800**	

Table 2
Orleans PRB Selection Matrix - PRB Characteristics

Pleasant Bay Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	Roads	Saturated Thickness of PRB (ft)	Depth Range to Groundwater (ft)
Meeting House Pond	None					
Lonnies Pond/ Kescayo Gansett River						
Lonnies Pond/Kescayo Gansett River	Monument	25, 26 Lonnies Pond/Kescayo Gansett River	1,675	Monument	30	25 to 50
Aerys Pond	None					
Upper River						
Upper River	Keziahs	41 Upper River	1,250	Keziahs	30	15 to 40
Lower River						
Lower River	Mayflower	28 Lower River	1,700	Pershing, Kenneth	30	10 to 30
Namequoit River						
Namequoit River	Namequoit	30 Namequoit River	1,000	Namequoit Road	30	10 to 40
Namequoit River	Ridge	30 Namequoit River	460	Ridgewood Rd	30	10 to 30
Pah Wah Pond						
Pah Wah Pond	Lockwood	32 Pah Wah Pond	1,230	Lockwood	30	5 to 15
Quanset and Pleasant Bay Main Basin						
Quanset and Pleasant Bay Main Basin	Quonset 1,2,3	33, 37 Pleasant Bay and Quanset Pond	1,745	Towhee, Lake Dr, Oyster	30	10 to 40
Quanset and Pleasant Bay Main Basin	Grannys	33, 37 Pleasant Bay and Quanset Pond	650	Grannys	30	15 to 20
Quanset and Pleasant Bay Main Basin	Winslow	33, 37 Pleasant Bay and Quanset Pond	1,150	Winslow Dr and Way	30	5 to 40
Quanset and Pleasant Bay Main Basin	Richwood	33, 37 Pleasant Bay and Quanset Pond	890	Richwood Farm	30	10 to 15
Pochet						
Pochet	Duck Hole	35 Pochet Neck Stream	4,100	High View, Old Duck Hole, Lovell	30	5 to 35
Pochet	Gosnold	34, 35 Pochet and Pochet Neck Stream	2,081	Gosnold,	30	10 to 30
Pochet	Briar Spring	34 Pochet	2,906	Briar Spring	30	10 to 35
Pochet	Blossom	34 Pochet	400	Blossom , Sparrowhawk	30	30 to 40
Pleasant Bay Estuary (Orleans)			**21,237**			

Nauset Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	Roads	PRB Saturated Thickness (ft)	Depth Range to Groundwater (ft)
Town Cove						
Town Cove	Tonset	5 Town Cove	7,300	Gibson, Tonset	30	10 to 30
Town Cove	Main	5 Town Cove	850	Main	40	5 to 10
Mill Pond						
Mill Pond	Norseman	8 Mill Pond	580	Norsemans Road, Mill Pond Rd	40	10 to 35
Nauset Estuary (Orleans)			**8,730**			

Rock Harbor Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	Roads	PRB Saturated Thickness (ft)	Depth Range to Groundwater (ft)
Rock Harbor Main	Rock Harbor					
Rock Harbor	Rock Harbor	3 Rock Harbor Main	3,940	Rock Harbor	50	5 to 15
Rock Harbor Estuary (Orleans)	Rock Harbor		**3,940**			

PRB Townwide Potential Total			**33,907**			

Table 3
Orleans PRB Selection Matrix - Effectiveness

Pleasant Bay Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	Estimated Number of Parcels	Estimated Sewer Load reduced (kg/yr) at 80% PRB Efficiency	Embayment Non-Traditional Technology Goal (kg/yr)	Percentage Removed	Estimated PRB Efficiency (kg/LF/yr)	PRB Watershed Efficincy Rank (kg/yr)	Evaluation Notes
Meeting House Pond	None			**0**	**0**	**40**	**0**			Traditional Technology to be Used
Lonnies Pond/Kescayo Gansett River				**41**	**178**	**284**	**63**			
Lonnies Pond/Kescayo Gansett River	Monument	Gansett River	1,675	41	178			0.11	**8**	Upper Reach Priority embayment
Aerys Pond	None			**0**	**0**	**113**	**0**			
Upper River				**26**	**113**	**202**	**56**			
Upper River	Keziahs	41 Upper River	1,250	26	113			0.09	**9**	Upper Reach Priority embayment
Lower River				**35**	**152**	**517**	**29**			
Lower River	Mayflower	28 Lower River	1,700	35	152			0.09	**11**	Upper Reach Priority embayment
Namequoit River				**56**	**244**	**348**	**70**			
Namequoit River	Namequoit	30 Namequoit River	1,000	27	117			0.12	**6**	Upper Reach Priority embayment
Namequoit River	Ridge	30 Namequoit River	460	29	126			0.27	**1**	Upper Reach Priority embayment
Pah Wah Pond				**35**	**152**	**413**	**37**			
Pah Wah Pond	Lockwood	32 Pah Wah Pond	1,230	35	152			0.12	**5**	Upper Reach Priority embayment
Quanset and Pleasant Bay Main Basin				**122**	**531**	**1,485**	**36**			
Quanset and Pleasant Bay Main Basin	Quonset 1,2,3	Pond	1,745	43	187			0.11	**7**	Upper Reach Priority embayment
Quanset and Pleasant Bay Main Basin	Grannys	Pond	650	24	104			0.16	**4**	Lower Priority
Quanset and Pleasant Bay Main Basin	Winslow	Pond	1,150	14	61			0.05	**14**	Lower Priority
Quanset and Pleasant Bay Main Basin	Richwood	Pond	890	41	178			0.20	**2**	Lower Priority
Pochet				**171**	**744**	**1,564**	**48**			
Pochet	Duck Hole	35 Pochet Neck Stream	4,100	68	296			0.07	**12**	Upper Reach Priority embayment
Pochet	Gosnold	Stream	2,081	29	126			0.06	**13**	Upper Reach Priority embayment
Pochet	Briar Spring	34 Pochet	2,906	59	257			0.09	**10**	Upper Reach Priority embayment
Pochet	Blossom	35 Pochet	400	15	65			0.16	**3**	Upper Reach Priority embayment
Pleasant Bay Estuary (Orleans)			**21,237**	**486**	**2,115**	**4,966**	**43**			

Nauset Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	Estimated Number of Parcels	Estimated Sewer Load reduced (kg/yr) at 80% PRB Efficiency	Embayment Non-Traditional Technology Goal (kg/yr)	Percentage Removed	Estimated PRB Efficiency (kg/LF/yr)	PRB Watershed Efficincy Rank (kg/yr)	Evaluation Notes
Town Cove				**171**	**744**	**566**	**131**			
Town Cove	Tonset	5 Town Cove	7,300	93	405			0.06	**3**	Upper Reach Priority embayment
Town Cove	Main	5 Town Cove	850	78	339			0.40	**1**	Upper Reach Priority embayment
Mill Pond				**28**	**122**	**0**				
Mill Pond	Norseman	8 Mill Pond	580	28	122			0.21	**2**	Lower Priority
Nauset Estuary (Orleans)			**8,730**	**199**	**866**	**566**	**153**			

Rock Harbor Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	Estimated Number of Parcels	Estimated Sewer Load reduced (kg/yr) at 80% PRB Efficiency	Embayment Non-Traditional Technology Goal (kg/yr)	Percentage Removed	Estimated PRB Efficiency (kg/LF/yr)	PRB Watershed Efficincy Rank (kg/yr)	Evaluation Notes
Rock Harbor Main	**Rock Harbor**			**70**	**305**	**634**	**48**			
Rock Harbor	Rock Harbor	3 Rock Harbor Main	3,940	70	305			0.08	**1**	Upper Reach Priority embayment
Rock Harbor Estuary (Orleans)	**Rock Harbor**		**3,940**	**70**	**305**	**634**	**48**			

PRB Townwide Potential Total			**33,907**	**755**	**3,286**					

Table 4
Orleans PRB Selection Matrix - Cost

Orleans Potential Full Scale PRBs - Pleasant Bay

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	PRB Installation Cost Estimate (Using Avg. $/LF)	30-year LCCA for PRB	60-year LCCA for PRB	100-year LCCA for PRB
Meeting House Pond	None						
Lonnies Pond/Kescayo Gansett River							
Lonnies Pond/Kescayo Gansett River	Monument	25, 26 Lonnies Pond/Kescayo Gansett River	1,675	$2,060,250	$4,889,900	$11,771,500	$29,263,500
Aerys Pond	None						
Upper River							
Upper River	Keziahs	41 Upper River	1,250	$1,537,500	$3,775,700	$9,105,000	$22,593,400
Lower River							
Lower River	Mayflower	28 Lower River	1,700	$2,091,000	$4,969,200	$11,956,900	$29,715,300
Namequoit River							
Namequoit River	Namequoit	30 Namequoit River	1,000	$1,230,000	$7,577,200	$18,219,500	$45,400,700
Namequoit River	Ridge	30 Namequoit River	460	$565,800	Included with Namequoit PRB		
Pah Wah Pond							
Pah Wah Pond	Lockwood	32 Pah Wah Pond	1,230	$1,512,900	Included with Namequoit PRB		
Quanset and Pleasant Bay Main Basin							
Quanset and Pleasant Bay Main Basin	Quonset 1,2,3	33, 37 Pleasant Bay and Quanset Pond	1,745	$2,146,350	$5,071,900	$12,209,000	$30,358,200
Quanset and Pleasant Bay Main Basin	Grannys	33, 37 Pleasant Bay and Quanset Pond	650	$799,500	$2,174,200	$5,274,000	$13,024,100
Quanset and Pleasant Bay Main Basin	Winslow	33, 37 Pleasant Bay and Quanset Pond	1,150	$1,414,500	$3,496,900	$8,444,200	$20,954,000
Quanset and Pleasant Bay Main Basin	Richwood	33, 37 Pleasant Bay and Quanset Pond	890	$1,094,700	$2,805,100	$6,785,400	$16,804,500
Pochet							
Pochet	Duck Hole	35 Pochet Neck Stream	4,100	$5,043,000	$11,335,800	$27,203,000	$67,830,500
Pochet	Gosnold	34, 35 Pochet and Pochet Neck Stream	2,081	$2,559,630	$5,966,700	$14,355,900	$35,730,300
Pochet	Briar Spring	34 Pochet	2,906	$3,574,380	$8,168,400	$19,624,000	$48,891,500
Pochet	Blossom	35 Pochet	400	$492,000	$1,513,400	$3,693,000	$9,072,400
Pleasant Bay Estuary (Orleans)			**21,237**	**$26,121,510**	**$61,744,400**	**$148,641,400**	**$369,638,400**

Orleans Potential Full Scale PRBs - Nauset Estuary

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	PRB Installation Cost Estimate (Using Avg. $/LF)	30-year LCCA for PRB	60-year LCCA for PRB	100-year LCCA for PRB
Town Cove							
Town Cove	Tonset	5 Town Cove	7,300	$8,979,000	$22,059,000	$52,885,100	$132,049,100
Town Cove	Main	5 Town Cove	850	$1,045,500	Included with Tonset PRB		
Mill Pond							
Mill Pond	Norseman	8 Mill Pond	580	$713,400	$1,999,700	$4,855,300	$11,973,500
Nauset Estuary (Orleans)			**8,730**	**$10,737,900**	**$24,058,700**	**$57,740,400**	**$144,022,600**

Orleans Potential Full Scale PRBs - Rock Harbor

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	PRB Installation Cost Estimate (Using Avg. $/LF)	30-year LCCA for PRB	60-year LCCA for PRB	100-year LCCA for PRB
Rock Harbor Main	**Rock Harbor**						
Rock Harbor	Rock Harbor	3 Rock Harbor Main	3,940	$4,846,200	$10,896,700	$26,158,100	$65,232,700
Rock Harbor Estuary (Orleans)			**3,940**	**$4,846,200**	**$10,896,700**	**$26,158,100**	**$65,232,700**

PRB Townwide Potential Total			**33,907**	**$41,705,610**	**$96,699,800**	**$232,539,900**	**$578,893,700**

Table 5
Orleans Traditional Costs for Potential Full Scale PRB Areas

Orleans Traditional Costs for Potential Full Scale PRBs - Pleasant Bay

Embayment	PRB Name	Number of Parcels	Gravity Sewer (LF)	Low-Pressure Sewer (LF)	Pumping Station	Force Main (LF)	Highway Crossing	30-year LCCA for Traditional Treatment of PRB Area	60-year LCCA for Traditional Treatment of PRB Area	100-year LCCA for Traditional Treatment of PRB Area
Meeting House Pond	None									
Lonnies Pond/Kescayo Gansett River										
Lonnies Pond/Kescayo Gansett River	Monument	56	-	5,100	1	2,800	-	$11,229,800	$15,734,500	$27,359,400
Aerys Pond	None									
Upper River										
Upper River	Keziahs	38	-	4,620	1	1,050	0	$10,035,300	$14,393,400	$25,650,700
Lower River										
Lower River	Mayflower	39	-	6,120	1	2,400	-	$12,765,500	$18,543,100	$33,692,900
Namequoit River										
Namequoit River	Namequoit	112	-	12,030	1	2,330	-	$19,643,800	$29,703,600	$56,663,500
Namequoit River	Ridge	Included with Namequoit PRB								
Pah Wah Pond										
Pah Wah Pond	Lockwood	Included with Namequoit PRB								
Quanset and Pleasant Bay Main Basin										
Quanset and Pleasant Bay Main Basin	Quonset 1,2,3	48	-	7,370	1	6,925	-	$15,991,500	$22,244,300	$38,615,600
Quanset and Pleasant Bay Main Basin	Grannys	34	-	3,650	1	4,200	-	$10,881,800	$15,022,900	$25,634,900
Quanset and Pleasant Bay Main Basin	Winslow	33	-	3,100	1	1,100	-	$8,991,300	$12,956,400	$23,135,400
Quanset and Pleasant Bay Main Basin	Richwood	57	-	5,000	1	-	-	$11,027,600	$16,752,400	$31,824,500
Pochet										
Pochet	Duck Hole	49	-	12,240		-	-	$13,930,300	$22,394,800	$45,712,100
Pochet	Gosnold	43	-	5,250	1	1,450	-	$10,909,800	$15,672,600	$28,034,500
Pochet	Briar Spring	65	-	7,855	1	2,000	-	$14,027,700	$20,485,700	$37,516,300
Pochet	Blossom	22	-	1,925	1	1,350	-	$7,749,600	$10,875,800	$18,740,100
Pleasant Bay Estuary (Orleans)								**$147,184,000**	**$214,779,500**	**$392,579,900**

Orleans Traditional Costs for Potential Full Scale PRBs - Nauset Estuary

Embayment	PRB Name	Number of Parcels	Gravity Sewer (LF)	Low-Pressure Sewer (LF)	Pumping Station	Force Main (LF)	Highway Crossing	30-year LCCA for Traditional Treatment of PRB Area	60-year LCCA for Traditional Treatment of PRB Area	100-year LCCA for Traditional Treatment of PRB Area
Town Cove										
Town Cove	Tonset	229	11,000	9,850	1	3,500	-	$38,691,600	$57,626,500	$109,101,700
Town Cove	Main	Included with Tonset PRB								
Mill Pond										
Mill Pond	Norseman	37	-	3,200	1	7,000	-	$12,338,300	$16,772,700	$28,160,100
Nauset Estuary (Orleans)								**$51,029,900**	**$74,399,200**	**$137,261,800**

Orleans Traditional Costs for Potential Full Scale PRBs - Rock Harbor

Embayment	PRB Name	Number of Parcels	Gravity Sewer (LF)	Low-Pressure Sewer (LF)	Pumping Station	Force Main (LF)	Highway Crossing	30-year LCCA for Traditional Treatment of PRB Area	60-year LCCA for Traditional Treatment of PRB Area	100-year LCCA for Traditional Treatment of PRB Area
Rock Harbor Main	**Rock Harbor**									
Rock Harbor	Rock Harbor	81	0	8200	0	0	1	$10,994,600	$17,218,300	$34,367,700
Rock Harbor Estuary (Orleans)								**$10,994,600**	**$17,218,300**	**$34,367,700**

Traditional Costs for PRB Townwide Potential Total								**$209,208,500**	**$306,397,000**	**$564,209,400**

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Figures

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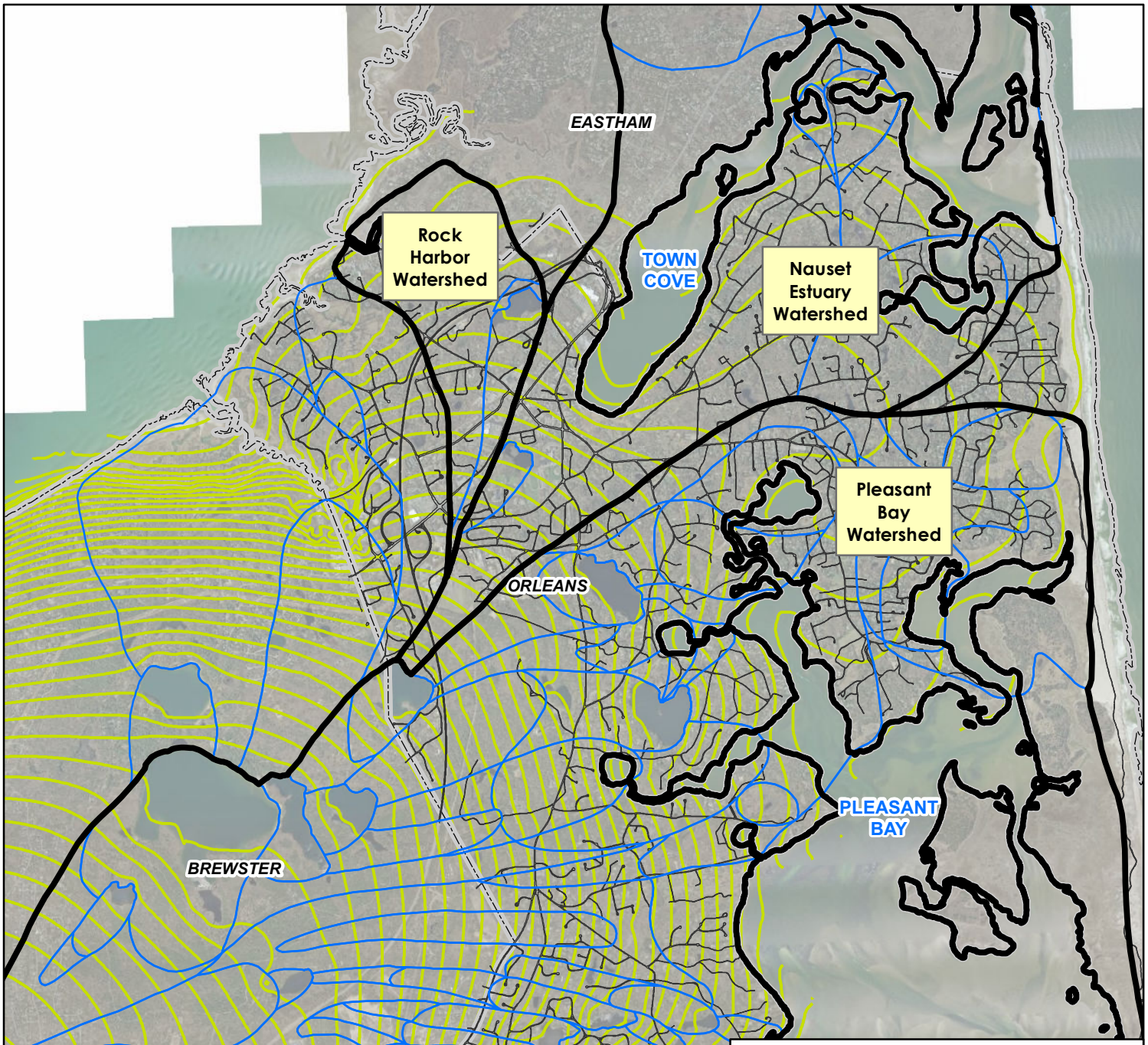


FIGURE 1

TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING

MAJOR AND SUB-WATERSHEDS

Legend

- Groundwater Contour
- Edge of Pavement
- MEP Subwatershed
- Town Boundary

1 inch = 4,000 feet

0 2,500 5,000 Feet

AECOM

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AECOM

FIGURE 2
PARTICLE TRACKING

TOWN OF ORLEANS
MASSACHUSETTS

AUGUST 2020

N

0 600 1,200 2,400 3,600 4,800
Feet

Rock Harbor PRB
Rock Harbor
Little Namskaket
Cedar Pond
Rock Harbor Watershed
Namskaket
Tonset PRB
Town Cove
Nauset Estuary Watershed
Norseman PRB
Mill Pond
Main St PRB
Pleasant Bay Watershed
Duck Hole PRB
Gosnold PRB
Meetinghouse Pond
Uncle Harvey's Pond
Blossom PRB
Briar Spring PRB
Pochet
Crystal Lake
Keziah's PRB
Upper River
Lonies Pond
Monument PRB
Mayflower PRB
Baker's Pond
Pilgrim Lake
Lower River
Namequoit River
Arey's Pond
Namequoit PRB
Ridge PRB
Lockwood PRB
Richwood PRB
Grannys PRB
Uncle Israel's Pond
Twinings Pond
Sarah's Pond
Shoal Pond
Meadow Bog Pond
Deep Pond
Quanset 3 PRB
Quanset
Quanset 2 PRB
Quanset 1 PRB
Winslow PRB
LITTLE PLEASANT BAY
HARWICH
PLEASANT BAY
CHATHAM

Legend

- Permeable Reactive Barrier
- Paths
- MEP Subwatershed
- Potable Well
- Potential Potable Well - VERIFY
- 208_Embayments
- Parcel with PRB (755)
- Other Parcels (4,705)

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Appendix A: Implementation Plan for Full-Scale PRBs

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AECOM
9 Jonathan Bourne Drive
Pocasset, MA 02559
www.aecom.com

508.833.6950 tel
508.833.6951 fax

Memorandum

To	George Meservey, Director of Planning & Community Development
CC	Betsy Shreve, AICP, AECOM Project Director James Begley, LSP, MT Environmental AECOM PRB Team
Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task 11.1.B.2 - Permeable Reactive Barriers (PRB)** **Implementation Plan for Full-Scale PRBs - Final**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	August 6, 2018

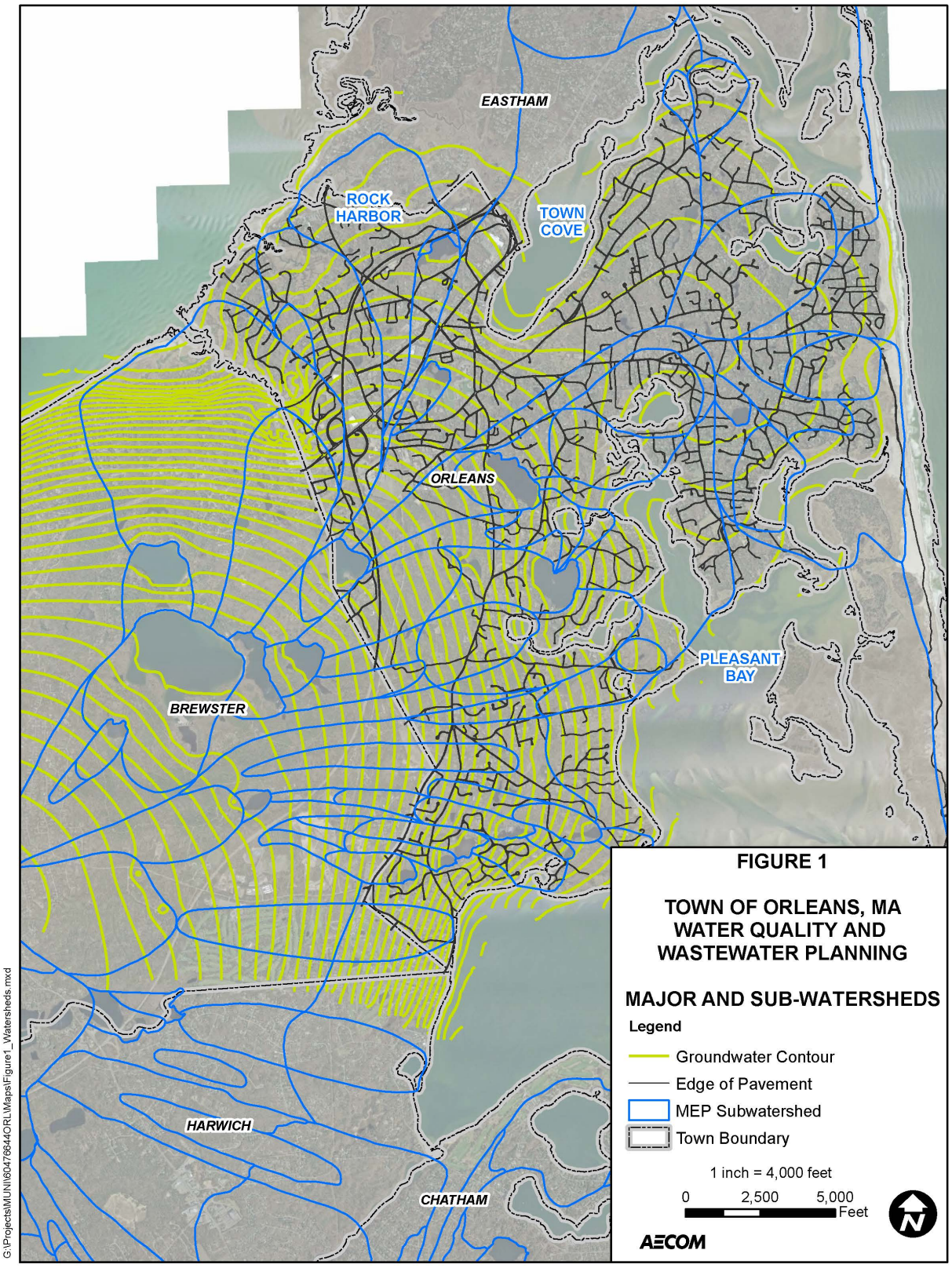
Approvals	Date	Signature / Initials
George Meservey, Orleans, MA Director of Planning & Community Development		

1. Introduction

This full-scale Permeable Reactive Barrier (PRB) Implementation Plan has been developed on behalf of the Town of Orleans Massachusetts (the Town) and includes preliminary design information and planning steps necessary for successful application of PRBs to reduce nitrogen loading to estuaries in Orleans. The estuaries include Rock Harbor, Nauset Estuary, and Pleasant Bay with proposed PRB systems in their respective watersheds. The PRBs will treat watershed nitrate prior to discharge to surface waters and be located to provide the most cost-effective treatment. The objective of this Implementation Plan is to provide preliminary design information and identify actions necessary to permit and install the PRBs and achieve verified nitrogen reductions. This plan identifies several potential PRB locations, but final locations will be selected after assessment of potential sites and public input on the proposed locations.

2. Background

Major watersheds in the Town include Nauset Harbor and Pleasant Bay sub-watersheds within the Atlantic Ocean watershed, and Namskaket Creek, Little Namskaket Creek, and Rock Harbor sub-watersheds within the Cape Cod Bay watershed. The groundwater system comprising these watersheds is part of the Monomoy Lens of the Cape Cod Aquifer. These major watersheds are characterized by numerous sub-watersheds contributing groundwater discharge to freshwater ponds, and estuaries including bays, salt ponds, and inlets as shown in Figure 1. Nitrogen in the form of nitrate, mainly from septic systems and fertilizer use is released to groundwater in the watersheds and then moves as a large dilute plume with groundwater flow and eventually discharges to the estuaries and coastal waters. This groundwater source of nitrogen is combined with additional sources such as stormwater runoff and fertilizer resulting in significant nitrogen loading to the surface water. When nitrogen loading reaches a certain threshold, it causes eutrophication or over enrichment of nutrients in estuaries resulting in algae blooms, scum layers, unpleasant odors, and periodic fish kills due to low oxygen conditions.


EASTHAM
ROCK HARBOR
TOWN COVE
ORLEANS
PLEASANT BAY
BREWSTER
HARWICH
CHATHAM
G:\Projects\MUNI\60476644\ORL\Maps\Figure1_Watersheds.mxd
FIGURE 1
TOWN OF ORLEANS, MA
WATER QUALITY AND
WASTEWATER PLANNING
MAJOR AND SUB-WATERSHEDS
Legend
Groundwater Contour
Edge of Pavement
MEP Subwatershed
Town Boundary
1 inch = 4,000 feet
0
2,500
5,000
Feet
AECOM

To address these concerns and comply with the Clean Water Act, the Town prepared a Comprehensive Wastewater Management Plan (CWMP) in December 2010. In response to comments on the CWMP, the Town re-evaluated its previously recommended approach to nitrogen control, which focused on installation of an extensive sewage collection system and new treatment facility with discharge at the Tri-Town Septage Treatment Facility site.

Subsequently, a draft Amended Comprehensive Wastewater Management Plan (ACWMP) was developed to document proposed changes including a revised Hybrid Plan. The ACWMP was developed in accordance with the Cape Cod 208 Water Quality Plan, which has been approved by both the United States Environmental Protection Agency (US EPA) and the Massachusetts Department of Environmental Protection (MassDEP).

The 25 percent Preliminary Design Report (PDR) plans for sewers in two areas including approximately 330 parcels encompassing the Downtown Area and approximately 406 parcels within the Meetinghouse Pond Area.

As this time, the revised ACWMP Hybrid Plan also included provisions for use of non-traditional technologies including PRBs and shellfish propagation to control nitrogen including an ongoing aquaculture demonstration in Lonnies Pond. Demonstrations for both PRBs and shellfish propagation are currently underway. Using these non-traditional technologies allows for reduced sewer collection system coverage while still achieving nitrogen control objectives. Permeable Reactive Barriers (PRBs) provide a way to intercept nitrogen in groundwater at key locations in the watersheds before it reaches sensitive embayments.

A PRB Demonstration Test has been implemented at the Eldredge Park Way location in Orleans to assess feasibility, determine PRB nitrogen removal efficiency, and assess the environmental sustainability of the alternative. The demonstration project was implemented in November 2016, was expanded in June 2018 and is subject to an intensive ongoing monitoring program to quantify nitrogen removal and secondary water quality effects. The cost for the three year demonstration test (investigations, implementation, expansion and monitoring) is approximately $917,000. Preliminary monitoring data indicate that the PRB is serving to reduce nitrogen concentrations in groundwater without significant secondary water quality impacts. Information gained through the demonstration will be utilized in determining final engineering details for full-scale implementation, refining monitoring plans, and predicting nitrogen removal efficiency for cost effectively achieving water quality goals.

3. Permeable Reactive Barrier Technology

A PRB is a passive treatment technology, designed in this application to in tercept and treat nitrate in groundwater through biological denitrification before the groundwater reaches downgradient surface waters. The PRB treatment zone is installed in the groundwater saturated zone below the water table, where amendments are added by injection to form the PRB. PRBs are typically oriented perpendicular to the direction of groundwater flow as shown in Figure 2 and rely on the natural groundwater gradient to carry nitrate to the PRB. The system is permeable because the injected amendments are designed not to interfere with groundwater flow, only removing nitrate as the groundwater passes through.

Key Terms

Permeable Reactive Barrier (PRB)
A zone of enhanced denitrification formed in the path of a dissolved nitrate plume.

Denitrification
Biological conversion of nitrate in water to inert nitrogen gas by naturally occurring bacteria. Denitrification: $NO_3^- \rightarrow N_2$ (gas)

PRB Amendment
Emulsified vegetable oil (EVO) used to provide dissolve organic carbon to stimulate naturally occurring bacteria in groundwater to transform nitrate to inert nitrogen gas.

Preliminary Design
Provides a concept with typical layout, materials, and steps to install the PRBs and associated cost elements.

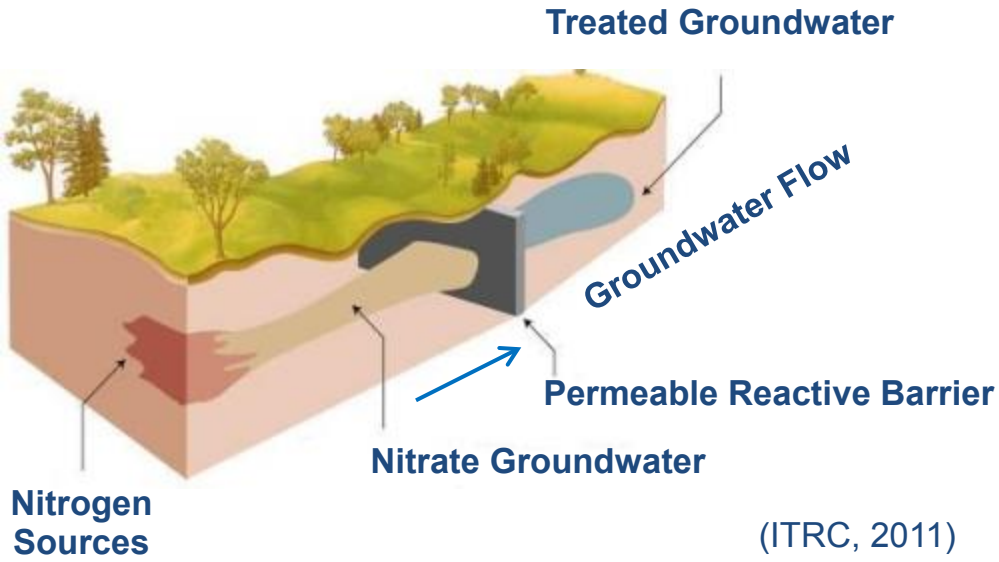


Figure 2 - Permeable Reactive Barrier

The injected amendment used to form the PRB is typically emulsified vegetable oil (EVO), a source of dissolved organic carbon that stimulates naturally occurring microbes in the groundwater to consume the dissolved organic carbon while respiring oxygen and creating anoxic conditions (without oxygen) favorable for denitrifying bacteria. The denitrifying bacteria then continue to use the dissolved organic carbon while respiring nitrate. This process of bacterial metabolism results in the conversion of nitrate to inert nitrogen gas. The PRB will need to be rejuvenated with additional EVO injections following an extended period of operation to replenish the consumed organic carbon.

4. Water Quality Goals

A. General

Development of surface water quality goals in the form of Total Maximum Daily Loads (TMDLs) is required by the Federal Clean Water Act. To develop embayment specific TMDLs, the Massachusetts Estuaries Project (MEP) have assessed nitrogen loading to the estuaries using an analytical method called the Linked Watershed-Embayment Management Modeling Approach. The model links watershed nitrogen inputs with surface water circulation and nitrogen characteristics. The TMDLs define the maximum nitrogen loads that the water bodies can receive while still meeting necessary water quality criteria. Corrective actions are then necessary to reduce nitrogen loading to below the TMDLs.

TMDLs developed by MEP have been documented in technical reports prepared for Pleasant Bay, Rock Harbor, and the Nauset Estuary (MEP 2006, MEP 2007, MEP 2012). Based on the TMDLs developed by the MEP, the MassDEP and US EPA have approved nitrogen TMDLs for Pleasant Bay. Additional TMDLs are undergoing review by the regulatory agencies. MEP assessments of Namskaket and Little Namskaket Creeks indicated no exceedances of developed TMDLs.

B. Pleasant Bay TMDLs

Pleasant Bay is connected to the Atlantic Ocean and is characterized by three main basins including Little Pleasant Bay, Pleasant Bay, and Chatham Harbor. The bay has a long shoreline and numerous sub-embayments. These sub-embayments are at particular risk of eutrophication from high nitrogen loads entering by direct groundwater discharge and restricted tidal exchange. Main basins in or adjacent to Orleans include Pleasant Bay Main Basin and Little Pleasant Bay. The sub-embayments in Orleans include Meetinghouse Pond, the Upper and Lower River, Lonnies Pond, Namequoit River and Aries Pond, Paw Wah Pond, Quanset Pond, and Pochet Inlet.

MEP issued the report "Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Pleasant Bay System, Orleans, Chatham, Brewster and Harwich, Massachusetts" in May 2006 that included proposed TMDLs for the system. On June 23, 2017 the Select Boards of Brewster, Chatham, Harwich and Orleans voted to sign a Resolution of the Towns sharing the Watershed of Pleasant Bay, endorsing the Pleasant Bay Composite Nitrogen Management Analysis as an accurate representation of each Town's share of current attenuated nitrogen load and its responsibility to remove nitrogen in Pleasant Bay (Pleasant Bay Alliance, March 2017). The agreed Town of Orleans share of attenuated Pleasant Bay Watershed nitrogen load is 6,980 kg/yr. The Towns sharing the watershed of Pleasant Bay entered an inter-municipal memorandum of agreement in 2018 to coordinate resource management of Pleasant Bay among the member Towns through the Pleasant Bay Alliance. The Pleasant Bay Alliance developed nitrogen removal requirements by Town and by Sub-embayment identifying these requirements is shown on Table 1 (Pleasant Bay Alliance March 2017).

C. Nauset Harbor Embayment System TMDLs

The Nauset Harbor Embayment System in Orleans and Eastham is comprised of open waters including Nauset Harbor and Town Cove, Nauset Marsh, located behind Nauset Barrier Beach, and three sub-embayments including Salt Pond, Wood Cove, and Mill Pond. The Nauset Harbor Estuary watershed is in the Towns of Orleans, Eastham, and Brewster. The most impacted areas with impaired habitat, and therefore the focus of nitrogen load reduction in Orleans, include the upper reach at Town Cove and the semi-enclosed Mill Pond and Wood Cove sub-embayments. The Salt Pond sub-embayment in Eastham is also at risk of eutrophication. MEP issued the report "Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Nauset Harbor Embayment System, Towns of Orleans and Eastham, Massachusetts" in 2012 that included TMDLS for the estuary.

Based on the draft ACWMP, the required nitrogen removal by Orleans for the Nauset system is 5,442 kg/yr, with a PRB technology removal target of 566 kg/yr focused on Town Cove.

D. Rock Harbor TMDLs

The watershed for Rock Harbor is in the Towns of Orleans and Eastham. Rock Harbor is a man-made harbor at the mouth of a tidal river and salt marsh and opens to Cape Cod Bay to the north. Significant habitat quality impairment and the presence of algal mats have been observed in the lower reach harbor area, while the upper reach marsh area has higher quality habitat. MEP issued the report "Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Rock Harbor Embayment System, Towns of Orleans, Massachusetts" in December 2008 that included TMDLs for the estuary.

Based on the draft ACWMP, the required nitrogen removal by Orleans for Rock Harbor is 1,463 kg/yr, with a PRB technology removal target of 634 kg/yr.

Table 1 - Pleasant Bay Composite Nitrogen Management Analysis
Nitrogen Removal Requirements by Town and by Sub-embayment (kg/yr)
(Pleasant Bay Alliance March 2017)

Pleasant Bay Composite Nitrogen Management Analysis

Table 1. Nitrogen Removal Requirements by Town and by Subembayment (kg/yr)

Subembayment	Brewster	Chatham	Harwich	Orleans	Total
Meetinghouse Pond				1,876	1,876
Town Percent of Total Removal				100%	100%
Lonnies Pond	14			284	298
Town Percent of Total Removal	5%			95%	100%
Areys Pond	29			113	142
Town Percent of Total Removal	20%			80%	100%
The River - Upper	3			375	378
Town Percent of Total Removal	1%			99%	100%
The River - Lower	6			518	524
Town Percent of Total Removal	1%			99%	100%
Namequoit River	19			348	367
Town Percent of Total Removal	5%			95%	100%
Paw Wah Pond				413	413
Town Percent of Total Removal				100%	100%
Quanset Pond	29			227	256
Town Percent of Total Removal	11%			89%	100%
Round Cove	1		1,209		1,210
Town Percent of Total Removal	0.1%		99.9%		100%
Muddy Creek Upper		193	584		777
Town Percent of Total Removal		25%	75%		100%
Muddy Creek Lower		584	986		1,570
Town Percent of Total Removal		37%	63%		100%
Ryder's Cove		1,954			1,954
Town Percent of Total Removal		100%			100%
Crows Pond		0			0
Town Percent of Total Removal		-			-
Bassing Harbor		0			0
Town Percent of Total Removal		-			-
Frost Fish Creek		803			803
Town Percent of Total Removal		100%			100%
Pochet				1,569	1,569
Town Percent of Total Removal				100%	100%
Pleasant Bay (including Little Pleasant Bay)	2,161	542	1,620	1,257	5,580
Town Percent of Total Removal	39%	10%	29%	22%	100%
Chatham Harbor		0			0
Town Percent of Total Removal		-			-
Total (All Subembayments)	2,262	4,076	4,399	6,980	17,717
Town Percent of Total Removal	13%	23%	25%	39%	100%

Notes:
1. Blue shading denotes entries that are greater than 5% of total (more than 886 kg/yr).
2. Blue shaded entries account for 71% of overall requirement.
3. See Table A-2 and A-3 in Appendix A for derivation of load removal requirements.

5. Implementation Approach and Phasing of PRB Installations

A. General

Criteria and conditions that will drive the phasing of full scale PRB installations include:

- The progress and outcome of the ongoing PRB Demonstration Test;
- Regulatory permitting timelines;
- Selection and access to proposed PRB locations;
- Availability of staffing resources and implementation funds;
- Availability of carbon substrate, subcontractors, and equipment for monitoring well installation and PRB injection; and
- Adaptive management of PRB implementation.

The PRB design process will include four general steps. These steps are outlined below with approximate time frames:

- Initial planning (this Technical Memorandum);
- Preliminary assessments of potential PRB locations and coordination with stakeholders including public workshops (6-months);
- Investigation of short listed locations with hydrogeologic assessments to confirm groundwater flow, actual water quality, and feasibility (9-months); and
- Full-design (1-year).

B. Development of Project Costs

PRB implementation costs have been developed based on estimated linear feet of PRB implementation defined in the ACWMP and cost information from the demonstration test at Eldredge Parkway location. These costs are outlined in Table 2 and include:

- Town Administration and Engineering;
- Engineering - Planning/Consultation;
- Engineering – Design;
- Contractor mobilization and demobilization;
- Monitoring well drilling and installation;
- Monitoring plan and baseline assessment;
- PRB Injections and materials;
- First year monitoring program implementation; and
- Projected annual replacement costs for monitoring wells and PRB rejuvenation injections.

Key Terms

Implementation Costs
Related to costs to Implement or install the proposed PRB. Implementation Costs are generally financed through a loan or bond program. This provides up front funding for implementation, with principal and interest payments spread out over time.

Annual Operations and Maintenance (O&M) Costs
Related to the day-to-day running and upkeep of the system. O&M Costs include items such as labor, utilities, chemicals, etc.

Annual Replacement Costs
Related to the replacement and/or repair of monitoring wells that have been damaged as well as the annualize cost to re-inject EVO.

Annual Monitoring Costs
Related to the annual compliance monitoring determined by the MassDEP. Annual Monitoring Costs include items such as labor and laboratory analysis.

Table 2 - Estimated Costs (July 2018)

Component	Implementation Cost	Annual O&M Cost	Annual Replacement Cost	Annual Monitoring Cost
Site 1 – Rock Harbor Watershed (4,700 LF)				
Design	$518,600			
Implementation, O&M and Monitoring	$4,148,700	$0		$178,600
Replacement			$745,300	
Site 2 – Pleasant Bay Watershed (1,900 LF)				
Design	$210,700			
Implementation, O&M and Monitoring	$1,685,400	$0		$78,300
Replacement			$307,100	
Site 3 – Nauset Harbor Watershed (2,200 LF)				
Design	$244,500			
Implementation, O&M and Monitoring	$1,956,000	$0		$89,100
Replacement			$354,500	

Notes:

1. The design is expected to occur within a one-year period following site selection. The implementation, O&M, and monitoring is expected to begin after the design year, pending appropriation of funding at the prior year's Town Meeting/Special Town Meeting. The annualized replacement costs are anticipated to begin the year following implementation.
2. The estimated linear feet of PRB for the three sites is based on the 2015 Conceptual Approach developed by Stantec for the Town of Orleans. The estimated costs presented are based on these lengths and are expected to vary based on actual length determined during design development.

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 11117 for July 2018.

The probable project costs will need to be updated based on the actual implementation year.

C. Regulatory Permitting

Massachusetts Section 2A of Chapter 259 of the Acts of 2014 required MassDEP to develop a watershed permitting approach to address and optimize nitrogen management measures intended to restore water quality. Planning for Watershed Permits is included in the approved Cape Cod Nitrogen Management Plan (the 208 Plan Update) developed pursuant to Section 208 of the federal Clean Water Act. The 208 Plan Update designates Cape Cod Towns as Waste Treatment Management Agencies (WMAs) responsible for meeting TMDLs on a watershed basis.

In addition to the Watershed Permit, site specific permitting requirements for PRBs will depend on the proposed location. PRBs will be proposed outside of wetland resource areas and sensitive environmental locations where possible. The preferred approach is to install PRBs through Town roads or rights-of-way or potentially on Town-owned properties. Potential permitting requirements and approving authorities are included in Table 3 and described below.

Table 3 - Potential Permit Requirements Depending on Location

Permit	Regulation	Administrating Agency
Massachusetts Environmental Policy Act Permit	Massachusetts Environmental Policy Act Unit	MEPA Unit
Underground Injection Control Registration	Safe Drinking Water Act	MassDEP
Section 106 & Chapter 254 Historic Preservation Act Compliance	Section 106 of the National Historic Preservation Act	Massachusetts Historical Commission
Massachusetts Endangered Species Act Project Review	Massachusetts Endangered Species Act	Massachusetts Division of Fisheries and Wildlife Natural Heritage & Endangered Species Program
Notice of Intent/Order of Conditions	Wetlands Protection Act/ Rivers Protection Act	Town of Orleans Conservation Commission and MassDEP
Road Opening Permits	Massachusetts Chapter 82A Sections 40 through 40D	Town of Orleans Highway Department

D. Massachusetts Environmental Policy Act

PRB projects may be subject to the Massachusetts Environmental Policy Act (MEPA) 301 CMR 11.00. MEPA review is required when one or more review thresholds are met or exceeded and the subject matter of at least one review threshold is within MEPA jurisdiction. In determining whether a Project is subject to MEPA jurisdiction or meets or exceeds any review thresholds it may be necessary to consider all proposed PRBs together to avoid segmentation concerns.

An Environmental Notification Form (ENF) describing the project and potential environmental impacts along with any feasible measures to mitigate potential environmental damage is submitted to the Executive Office of Energy and Environmental Affairs (EEA). EEA solicits comments from the public and state agencies. Following public comment and consultation, the EEA issues a Certificate stating whether an Environmental Impact Report (EIR) is needed and what the scope of the EIR should include, if required. If the EIR is not required, the state permitting agencies can issue the required permits and the project can go forward. Projects located in designated Areas of Critical Environmental Concern require ENF and a Mandatory EIR. Both Pleasant Bay and Rock Harbor are located within state-designated Areas of Critical Environmental Concern.

E. Underground Injection Control Registrations

PRBs will require a MassDEP issued Underground Injection Control (UIC) Registration to comply with UIC Regulations. The UIC Program is responsible for regulating the implementation, operation, permitting, and closure of injection wells that place fluids underground for storage and disposal. The UIC Program requirements were developed by EPA and designed to be adopted by states. The MassDEP UIC Program, defined in 310 CMR 27.00: Underground Injection Control Regulations, details the regulation of injection of fluids within Massachusetts.

To implement a PRB a UIC permit application (MassDEP form BRPWS 06) must be filed with MassDEP under the category “Aquifer Remediation”. The application would include the design parameters and layout of the PRB along with a Water Quality Monitoring Plan. Similar injections of carbon substrates to enhance biodegradation of groundwater chemicals have been commonly implemented in Massachusetts and many of these sites are exempt from the UIC registration process if the injections are conducted for waste site cleanup in accordance with the Massachusetts Contingency Plan (MCP, 310 CMR 40.0000) or similar federal statutes. PRBs will be implemented in compliance with the requirements of the Massachusetts UIC regulations, including all required monitoring. A fee of $585 for each PRB site would be associated with filing the UIC permit. The UIC permit applications should be submitted at least 60 days in advance of the proposed PRB implementation start date. Status reports documenting PRB implementation and monitoring results are subsequently submitted to MassDEP.

F. Historic Preservation Act

At certain locations project review by the Massachusetts Historical Commission (MHC) may be necessary. The MHC administers the Historic Preservation Act. Any projects that require funding, licenses, or permits from any state agency must be reviewed by MHC in compliance with Massachusetts General Laws Chapter 9, sections 26-27C. This law creates the MHC, the office of the State Archaeologist, and the State Register of Historic Places among other historic preservation programs. It provides for MHC review of state projects, State Archaeologist’s Permits, the protection of archaeological sites on public land from unauthorized digging, and the protection of unmarked burials. The regulations that guide MHC review of state funded, licensed or permitted projects are published in 950 CMR 71. These regulations set up a process for the identification of historic properties, assessment of effect, and consultation among interested parties to avoid, minimize, or mitigate any adverse effects. Projects on slopes or uplands adjacent to rivers, lakes, ponds and the ocean are generally considered to be more sensitive to the presence or archaeological artifacts than other locations. Following consultation with MHC, a Project Notification Form (PNF) is submitted to initiate MHC review. The PNF includes a description of the proposed project, existing conditions, and past development of disturbances in the project area.

G. Massachusetts Endangered Species Act Project Review

Projects and activities within rare species habitat must file with the Natural Heritage & Endangered Species Program (NHESP) for review and approval. Habitats in Massachusetts have been mapped as Priority & Estimated Habitats and maps are available on-line. In review, NHESP determines whether the project, as proposed, will impact state-listed species and their habitats and whether or not a project or activity as proposed will result in a "Take" of state-listed species. Projects may have to be revised to avoid a “Take” or be subject to conditions or restrictions to avoid impacts to state-listed species and their habitats and must meet the performance standards for the issuance of a Conservation and Management Permit.

H. Wetlands Protection Act/Rivers Protection Act

If the PRB project is located within 100 feet of a wetland resource area or within 200 feet of a designated riverfront area a Notice of Intent must be submitted for review by the Orleans Conservation Commission. The Commission will issue an Order of Conditions for an approved project.

I. Road Opening Permit

Additional local permits will include Road Opening Permits where PRBs are implemented by injecting through roadways. PRBs systems implementation and monitoring well installation will also likely require agreements for access to private property, mainly for the installation and sampling of monitoring wells.

6. Project Management and Predesign Planning

A. Implementation Team

The successful implementation of PRBs will require coordination between consultant/contractors and the Town of Orleans, including coordination of location access and permit approvals from Town, county, and state authorities. Teams will include:

- Designated Town Officials and Legal staff;
- Consultant staff, with Injection, Drilling, and Laboratory Sub-contractors; and
- Public Participation Coordinator.

It is anticipated that the Town of Orleans will assign a Town Project Manager within the Department of Public Works and Natural Resources and/or an Owner’s Program Manager for implementation coordination. The Consultant will work with the Town Project Manager and a team of specialty subcontractors to plan and implement PRBs. Due to the nature of the project, Town legal staff assistance will be needed to coordinate location access and assistance with permitting. A public participation coordinator will help facilitate public involvement in the project.

B. Pre-implementation Tasks

A detailed project schedule and project progress tracking and reporting system will be developed to identify action items to keep the project on course. The limits of target geographic areas and limits on existing land use for PRB implementation will be developed to inform location selection and monitoring program design and assure that planning is integrated with the ACWMP.

A process for review of specific potential PRBs and location selection, including public participation, will be developed by the Implementation Team to screen candidate PRB sites. The process will include coordination with the US EPA, MassDEP, Cape Cod Commission, and the Pleasant Bay Alliance, a municipal organization formed by the Towns of Orleans, Chatham, Harwich and Brewster to coordinate the resource management plan for the Pleasant Bay Area of Critical Environmental Concern and watershed. It is anticipated that coordination with the Town of Eastham will also be included in the process where PRBs may address shared resources (e.g. Nauset Estuary and Rock Harbor). Following development of a location short list, selected locations will be subject to further investigation to determine specific land use, location of utilities, and an initial groundwater assessment that will be integrated with Water Quality Monitoring Plans described below.

C. Locations Specific Assessment, Baseline Assessment, and Water Quality Monitoring Plans

Potential PRB locations will be reviewed and selected for implementation in accordance with the overall objectives of the Town Comprehensive Wastewater Management Plan, which includes priority areas. Prior to final selection, a location-specific assessment will be necessary to confirm the nature of hydrogeological conditions and groundwater chemistry for PRB design and monitoring plan development and to develop site specific costs on a cost per kilogram of nitrogen removed basis. The cost per kilogram will depend on implementation and monitoring costs, the dimensions of the PRB, and the flux of nitrate through the specific location.

Water Quality Monitoring Plans will be developed for each PRB location. The monitoring program will be developed based on the Conceptual Site Model for PRBs described below and will be developed in a phased approach. The first phase incorporates the initial location assessment, then builds in the baseline assessment needed before PRB implementation at a selected site, and finally the performance monitoring plan that will be used to track PRB efficiency and water quality affects. The assessments will include groundwater profiling and monitoring well sampling and analyses to assess nitrate mass flux and hydrogeologic conditions. Primary objectives of the monitoring plans are to:

- Evaluate potential PRB locations for selection and design based on mass flux of nitrate and feasibility of implementation;
- Assess potential reduction in nitrate concentrations in groundwater compared to baseline samples and/or wells upgradient of the PRB;
- Identify distance traveled by EVO emulsion and DOC;
- Identify extent of generated reducing conditions;
- Assess hydraulic performance;
- Evaluate persistence of EVO emulsion and anaerobic conditions favorable for denitrifying bacteria after PRB injection; and
- Assess changes in groundwater monitoring parameters.
- Estimate the cost per kilogram of nitrate removal.

The monitoring program will be designed to be dynamic and continuously evaluated to adjust the selected monitoring parameters and frequency of monitoring based on data collected and observations. A list of groundwater monitoring parameters is included in Table 4.

Table 4 - Summary of Potential Analyses for Groundwater Evaluation

Parameter	Relevance to PRB Demonstration Test
Nitrate	Primary groundwater compound targeted for treatment.
Nitrite	Intermediate nitrogen species from the aerobic nitrification of ammonia to nitrate.
Ammonia	Reduced inorganic nitrogen species that occurs in proximity of septic system leach fields and landfills.
TKN	Total Kjeldahl Nitrogen (TKN) is the total concentration of organic nitrogen and ammonia.
Total Nitrogen	Analyses provide a summation of all organic and inorganic nitrogen species in groundwater as a result of leach fields and landfill.
CENSUS-DNA (Denitrifying Bacteria)	Analysis quantifies relative abundance of denitrifying bacteria.
Metals (Fe, Mn, As)	Mobility of metals can be impacted by groundwater geochemistry changes, notably pH and ORP.
DOC	Dissolved Organic Carbon (DOC) is the limiting factor in enhancing denitrification-and is increased by injection of EVO. DOC tracks the area of influence of the PRB.
Sulfate	Sulfate will decrease with generation of sufficiently anaerobic conditions favorable for sulfate-reducing bacteria.
pH	Denitrification optimal pH (6.0 and 8.5). Groundwater pH can decrease as a result of fermentation of injected carbon substrates.
ORP	Oxidation-reduction potential (ORP) will decrease with generation of reducing conditions following injection of carbon substrate.
Chloride	Chloride concentrations indicate potentially infiltrating stormwater.
Alkalinity	Denitrification reactions generate alkalinity (3.57 mg of $CaCO_3$ for each mg of nitrate reduced).
Boron	Boron is present in laundry detergents and is an indicator of groundwater flow emanating from leach fields.

D. Adaptive Management

Coordinated implementation of PRBs is necessary to incorporate the Adaptive Management Approach as outlined in the CWMP, where non-structural elements such as PRBs can be implemented in a way that first documents their effectiveness and then allows their full application with predictable results and regulatory support, with the overall goal of reducing the cost of the structural elements. Adaptive Management Plan elements directly related to PRB implementation will require identification of tasks necessary to monitor and refine PRB placement, monitoring programs, and design and implementation methods moving forward. PRB monitoring programs can be integrated with long-term surface water quality monitoring programs for performance evaluation and optimization.

E. Environmental Considerations

Careful selection of PRB installation locations outside sensitive resource areas will be the primary means of minimizing environmental impact. Compliance with environmental permits will be necessary to assure environmental protection and permit requirements will be included in the progress tracking and recording system. Groundwater monitoring results from the Demonstration Test will be used to gauge the potential for secondary impacts to groundwater quality.

F. Conceptual Site Model for PRBs

Site specific PRB implementation assessment will be based on a Conceptual Site Model (CSM) developed for this project for PRBs based on groundwater conditions and the expected fate and transport of large dilute nitrate plumes on Cape Cod. The general (or Cape Cod) CSM is presented with a visualization in Figure 3 and described below.

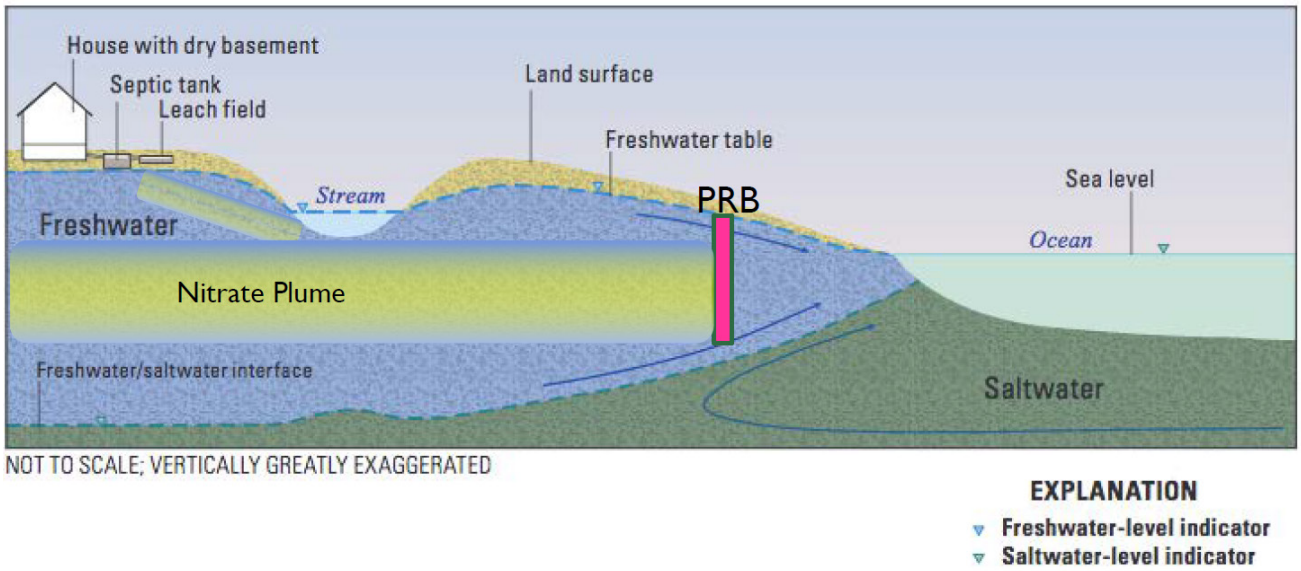
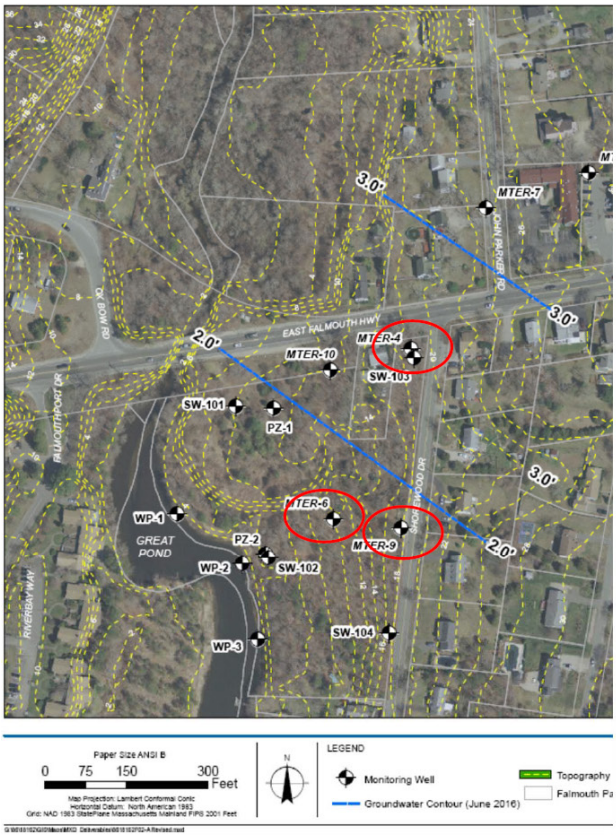


Figure 3 - Visual of Nitrate Plume Treatment PRB
Modified from USGS

Elements of the CSM include the following:

- Groundwater generally flows from the highest water table elevations in the watershed (e.g. approximately 26 feet above sea level in the Nauset Watershed) downgradient toward the receiving surface water body (e.g. Town Cove). In addition to flowing horizontally downgradient, groundwater may flow vertically, recharging deeper portions of the aquifer 100 to 150 feet or more below sea level. Water table elevations vary locally resulting in deviations in local groundwater flow direction.
- The presence of nitrate and nitrate concentrations varies depending on the strength or number of sources upgradient of a location and on the geochemistry of the groundwater. The geochemistry affects fate and transport of nitrogen. Generally septic system nitrogen and nitrogen from fertilizers are released to aerobic groundwater where nitrate is the dominant and most persistent form of nitrogen. Where groundwater travels deep over long distances and into anoxic conditions, natural attenuation may occur. Under these circumstances the profile of nitrate concentrations from shallow to deep in groundwater may indicate that the highest concentrations are generally in shallower groundwater and lower concentrations at depth (see example in Figure 4 below). The profile will in part depend on the distance from sources to the PRB. In recharge areas the plume will move deeper as it travels downgradient.



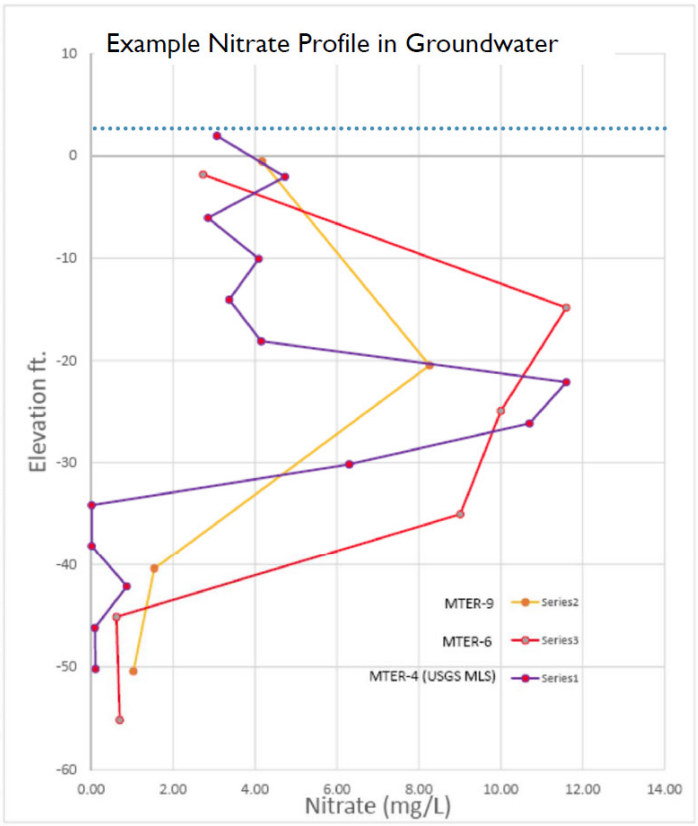


Figure 4 - Example Concentration Profile Nitrate in Groundwater on Cape Cod

- Groundwater flow through freshwater ponds may attenuate nitrogen concentrations.
- Groundwater velocity will vary depending on the local groundwater gradient and hydraulic conductivity of the aquifer material. The aquifer material may contain less permeable clay, silt or fine sand and higher permeability medium sand and gravel. The groundwater velocity may vary from less than 0.1 feet per day to more than 3 feet per day depending on local conditions.
- There may also be layering present in the aquifer material, with layers of more permeable coarser sand and gravel having higher hydraulic conductivity stratified with lower permeability fine sand, silt, or very low hydraulic conductivity clay layers. Mass flux of nitrate would be greater in more permeable layers with faster groundwater flow even if the concentration in lower permeability layers is similar.
- The nitrate treatment PRB will be installed to efficiently intercept the mass flux of nitrate in groundwater upgradient of the surface water to be protected.

The above CSM can be used to develop a site specific CSM to assist in PRB location assessment, PRB design, and development of site specific PRB groundwater monitoring plans. The assessments will include the installation of a set of initial monitoring wells and include groundwater profiling to confirm conditions at depth below the water table. Groundwater profiling will include an assessment of hydraulic conductivity and groundwater chemistry, including redox conditions and one or more nitrogen profiles for the location. Following evaluation of test results and confirmation of location selection, additional monitoring wells will be installed and sampled to establish sufficient information to confirm baseline conditions for comparison and performance assessment once the PRB is in place.

G. Conceptual PRB System Design

PRB conceptual design plans include an overview of installation activities, standard treatment layouts, facilities, and processes to be used to implement the PRB. The PRBs will be installed by injecting a diluted emulsified vegetable oil (EVO) substrate formulation specifically developed to treat nitrate in Cape Cod groundwater. The EVO is injected along a transect line that cuts across the plume of nitrate at the target PRB treatment location. The volume and mixture/type of EVO used to form the PRB will be designed based on the mass flux of nitrate and competing electron acceptors predicted with location specific assessment data. The assessment data may identify high flux zones that can then be targeted as the most cost-effective treatment locations and depths.

Key Terms

Mass flux
A rate measurement specific to a defined area, which is usually a subset of a plume cross section expressed as mass/time/area (e.g., g/d/m2) (ITRC 2010).

Conceptual Site Model (CSM)
Descriptive tool to help understand groundwater conditions and large dilute nitrate plumes on Cape Cod.

Hydraulic Gradient
Groundwater flows down the hydraulic gradient - water table elevations are determined by measuring the depth to water in three or more similar monitoring wells in an area and can then be used to triangulate the hydraulic gradient and horizontal flow direction.

The EVO will be injected with direct push rigs injection rigs (Figure 5) along an injection pathway set perpendicular or close to perpendicular to the groundwater flow direction. The direct push rigs use hydraulics and a vibratory hammer to drive hollow steel rods that serve as piping to the target injection depths. Target injection depths are expected to be up and potentially exceeding 100 feet below ground surface. Injections will be completed with a bottom up approach where the rig will drive direct push rods with typically 4 or 8-foot stainless steel laser cut screens at the bottom of the rods down to the deepest treatment interval. Following the first injection, the screen will be sequentially raised one screen length for subsequent injections until the top of the injection interval is reached.

Direct injection points (without permanent injection well structures) will be located 10 to 15 feet apart depending on the expected radius of influence of injected EVO at each PRB location as determined in the preliminary assessment. The layout and design injection depth will depend on the characteristics of the specific PRB location determined in the location specific assessment.

Design specifications include:

- Depth to ground water;
- PRB length (Linear Feet);
- Target treatment thickness;
- Injection point spacing;
- Number of injection points;
- EVO specification, dilution and additives;
- Injection pressure;



Figure 5 - Direct Injection Rig

- Injection target pore volume;
- Total injection volume (gal); and
- Injection volume per point (gal).

Where possible, PRBs will be implemented along the edge of roadways to minimize implementation related impacts. The objective is to install the PRB in such a way that, following injection, the only indication of the presence of the PRB on the land surface will be the flush mounted surface structure associated with the tops of monitoring wells.

The injection substrate will be delivered to a central staging location or the PRB location in bulk in plastic reusable totes in box trailers, diluted on-site with water to the required strength, and injected. Typically, multiple injection points will be injected simultaneously.

Given the potential length of full scale PRBs, significant advanced planning and coordination with suppliers and field crews will be required. Logistical considerations include:

- A single primary/central staging area will be needed for temporary storage of concentrated EVO in 275-gallon totes. Concentrated volumes required for each specific day can be pulled out of the central staging areas using fork lifts and loaded onto box trucks to move to secondary staging areas adjacent to injection areas. For projects with anticipated multiple secondary staging areas, the use of multiple box trucks can be utilized to minimize any downtime involved with transporting adequate EVO volumes.
- A hydrant water supply and/or water truck will be needed for supplying dilution water near each injection area. Required water supply flow on demand is approximately 40 to 60 gallons per minute.
- Alternatively, diluted EVO batches can be prepared at the central staging area and transported to injection areas on a daily or as-needed basis. Based on weight of water, approximately 6 to 8 totes are near the maximum volume (1,500 to 2,000 gallons) that can be carried in a box truck.
- EVO deliveries to central storage should be sequenced to keep minimum 2 to 3-day buffer to absorb faster/slower injection rates than anticipated. A daily delivery/consumption chart should be prepared and used to coordinate demand and delivery.
- Cumulative injection rates are important to maintain for large volume injections. To sustain high injection rates, 4 to 8 manifolded or dedicated injection lines may need to be operated simultaneously. At high flow rates appropriate staff levels will be needed to coordinate batching, injection, and transport of stock solution, diluted solutions, and/or water.
- Allowable working hours and days will need to be estimated prior to project implementation to effectively deliver EVO and to manage and maintain the injection schedule.
- Traffic flaggers and/or coordination with police for details will be important for maintaining safe working conditions. Police detail may be needed at the central staging area to minimize traffic disturbances with many large trucks arriving at a single location.

The injected EVO provides a long-term source of dissolved organic carbon within and immediately downgradient of the PRB. The dissolved organic carbon is a source of food for naturally occurring groundwater bacteria that will first utilize available oxygen in groundwater for respiration followed by denitrifying bacteria that will utilize nitrate for respiration. This natural process converts available nitrate nitrogen to inert nitrogen gas which is commonly present in groundwater. Once the required biological activity is established the PRB is expected to remove nitrate in groundwater for an extended period of years. The nitrogen load reduction that will be achieved can be predicted with the mass flux of nitrate identified in the assessment.

The process of establishing the PRB biological community in the treatment zones is expected to take several months based on the lag time for increases in naturally occurring biomass. The amount of time required to confirm the increase in biological activity (or biomass) will depend in part on the distance to downgradient monitoring wells along with groundwater velocity and travel time.

eventually, the efficiency of nitrate treatment will begin to decline once the carbon source starts to be depleted. Depletion is expected to occur in high mass flux areas first and will be indicated by decreasing dissolved organic carbon levels and increasing nitrate concentration at downgradient monitoring wells. Once the treatment efficiency decreases to a defined tolerance limit, rejuvenation of the PRB by subsequent injection will be required. The ongoing Demonstration Test is being monitored to assess longevity to provide specific guidance for PRBs in Orleans; expected operational time frames range from 5 to 10 years or more.

H. Post Implementation Tasks

Following implementation of individual PRBs an As-built Completion Report will be prepared documenting implementation, final inspections, and updated Water Quality Monitoring Plans. The report can then be used in conjunction with the Adaptive Management Approach, post installation monitoring, and reporting to track progress toward water quality goals.

7. References

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Pleasant Bay Alliance (2017) Pleasant Bay Composite Nitrogen Management Analysis

Attachment N

Technical Memorandum – Full-Scale Permeable Reactive Barriers Watershed Planning Investigation

AECOM
9 Jonathan Bourne Drive
Pocasset, MA 02559
www.aecom.com

508.833.6950 tel
508.833.6951 fax

Memorandum

To	George Meservey, Director of Planning & Community Development
CC	James Begley, LSP, MT Environmental AECOM PRB Team
Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 14.1.B.3** **Technical Memorandum: Permeable Reactive Barriers (PRB)** **Full-Scale Watershed Planning Investigation**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	January 30, 2023

1. Introduction

This Technical Memorandum has been prepared as part of the ongoing effort to identify and confirm potential full-scale Permeable Reactive Barrier (PRB) locations for implementation in accordance with the overall objectives of the Town of Orleans Amended Comprehensive Wastewater Management Plan (ACWMP). The current Memorandum documents the results of field subsurface investigations completed to assess four selected potential full-scale PRB locations in the Pleasant Bay Watershed. These four locations were selected for investigation following a PRB feasibility assessment and planning process documented in the Final Technical Memorandum: Permeable Reactive Barriers (PRB) Full-Scale Watershed Planning (AECOM 2021) included in Appendix A and further consultation with the Town of Orleans.

2. Background

A PRB is an innovative/alternative technology to traditional municipal wastewater collection, treatment, and discharge of treated effluent. PRBs are a decentralized passive treatment technology, designed to intercept and treat nitrate migrating in groundwater from diffuse sources and protecting downgradient salt ponds and embayments from nutrient overload. The PRB removes nitrate through denitrification, a biological process mediated by naturally occurring bacteria in groundwater before the groundwater reaches downgradient surface waters. Refer to **Figure A - Permeable Reactive Barrier**. A PRB is installed in the saturated zone below the water table where amendments, a food substrate for the bacteria, are added by injection to form the PRB. A population of denitrifying bacteria develops in the vicinity of the food substrate and utilizes that substrate over a long period of time. In the biological process, nitrate is converted to inert nitrogen gas. PRBs are typically oriented perpendicular to the direction of groundwater flow as shown in the diagram below and rely on the natural groundwater gradient and flow to carry nitrate to the PRB for removal.

The Town of Orleans implemented a successful multi-year pilot demonstration of the PRB technology. The Eldredge Park Way Demonstration Test PRB was installed in the parking lot area southwest of the Nauset Middle School in November 2016. Groundwater monitoring conducted before and after implantation has shown effective removal of nitrate from groundwater. That removal has continued though the most recent monitoring event in June 2022 and has been documented in quarterly reports provided to the Town.

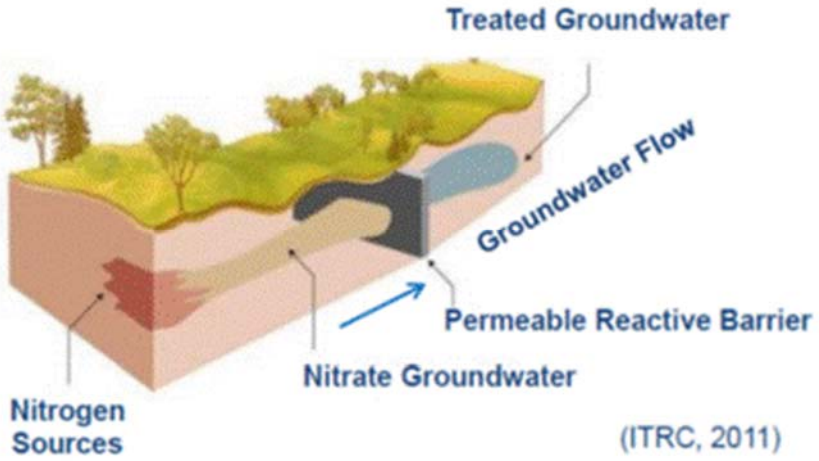


Figure A - Permeable Reactive Barrier

Demonstration test monitoring objectives included:

A. Assessing the potential reduction in nitrate concentrations in groundwater compared to baseline samples and/or wells upgradient of the PRB,

B. Identifying distance traveled by Emulsified Vegetable Oil (EVO) substrate and Dissolved Organic Carbon (DOC),

C. Identifying the extent of PRB generated nitrate reducing conditions,

D. Evaluating the potential for decrease in aquifer permeability because of EVO application, and

E. Evaluating the persistence of EVO and anaerobic conditions favorable for denitrifying bacteria after PRB injection.

Pilot PRB performance demonstrated that the PRB was effective at reducing significant nitrate concentrations, up to 39 mg/L in upgradient groundwater, to low concentrations or to below the detection limits of 0.03 mg/L immediately downgradient of the PRB.

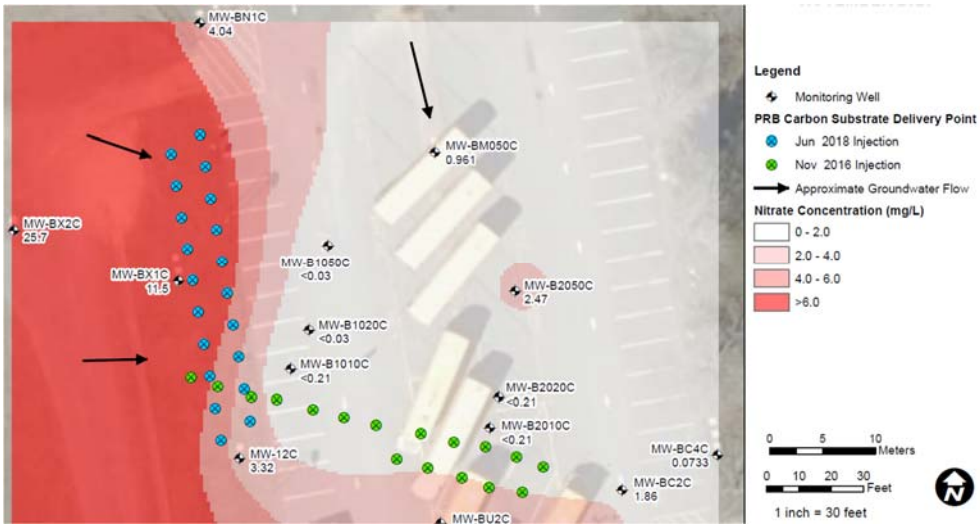


Figure B - Nitrate Removal at Eldredge Park Way Demonstration Test Site

No significant adverse effects of PRB implementation were identified in the assessment. The high nitrate concentration upgradient of the PRB is likely from the septic system serving the Nauset Regional Middle School. This represents a worst-case scenario for complete cut-off of nitrate flux, yet the PRB continues to remain effective; typical PRB applications would be for significantly lower groundwater nitrate concentrations from diffuse sources.

3. Full-Scale PRB Planning and Location Selection

Full scale PRB selection was conducted through a process that considered:

- Overall nitrogen remediation objectives,
- Environmental conditions and proximity to impacted sub-embayments,
- Land use, downgradient water use, and topography,
- Wastewater nitrogen load upgradient within the capture zone of the PRB, and
- Practical limitations like access and PRB installation depths for cost effective implementation of the technology.

The 2021 Full-Scale PRB Watershed Planning Memorandum documented the process including:

- Review of non-traditional technology objectives on a watershed and sub-watershed basis,
- Development of screening criteria, and screening of potential PRBs,
- Assessment of feasibility of implementation,
  - Life Cycle Cost Assessment (LCCA) - Comparing PRBs and Traditional system
  - Evaluation of pros and cons of full-scale PRBs as an alternative to traditional systems
- Determining optimal PRB dimensions,
- Modeling groundwater flow to define upgradient PRB Capture Zones (source area of groundwater flowing through PRBs),
- Assessing the density of wastewater sources in capture zones and potential nitrogen flux based on Massachusetts Estuary Program (MEP) defined source characteristics, and
- Comparing relative PRB efficiency and comparison of PRBs to traditional technology cost and nitrogen load reduction.

The outcome of this planning process for each of the three major Orleans watersheds was as follows:

- Pleasant Bay
  - Identification of 14 potentially viable PRBs,
  - Cumulative nitrogen removal of 2,115 kg/yr. of target 4,996 kg/yr.,
  - 13 recommended for further field assessment,
- Nauset Estuary
  - Identification of 3 potentially viable PRBs,
  - Cumulative nitrogen removal of 866 kg/yr. exceeding 566 kg/yr. target,
  - 2 recommended for further field assessment,
- Rock Harbor
  - Identification of 1 potentially viable PRB,
  - Nitrogen removal of 305 kg/yr. of target 634 kg/yr.,
  - Not recommended for further field assessment.

Further consultation with the Town of Orleans led to a focus on the Pleasant Bay Watershed for follow-on field assessment activities in the near term. The full list of potential Pleasant Bay Watershed PRBs is included in the PRB Screening Matrix included in Appendix B. It was decided to initially proceed with a subset of the full list of potential PRBs to focus and refine the field investigation process. Of the 14 potentially viable PRBs in the watershed, 9 were excluded from further investigation in the current effort due to their location on private roadways where private ownership was considered a short-term impediment to access for installation of monitoring wells and potentially the PRBs. Access to these locations require legal and administrative processes that will need to be addressed prior to proceeding with these locations. The 14 potential PRBs in the Pleasant Bay Watershed are included in Figure 1 along with other potential PRB locations in the watersheds to Rock Harbor and the Nauset Estuary. The locations of PRBs along roadways are shown in red and the capture zone of the PRBs is shown with blue lines tracing the groundwater flow path. The flow paths define the Capture Zone of the PRB and indicate the geographic source area for nitrate to be treated. Particle track modeling was used to trace back from the deepest installation depth of the PRB to the upgradient extent of the PRB capture zone. Groundwater flowing from upgradient of the Capture Zone would flow under the PRB as groundwater generally moves deeper with distance traveled.

Of the remaining five potential PRB locations in the Pleasant Bay watershed after eliminating PRBs located on private roads, four locations were selected for field subsurface investigations. These included PRBs on:

- Duck Hole Road,
- Briar Spring Road,
- Ridgewood Road (Ridge), and
- Namequoit Road.

These four PRB locations are indicated in boxes shown on Figure 1. The 5th location on Monument Road was eliminated due to the potential low-cost benefit rating of the location for a PRB and limited locations for safely installing monitoring wells along Monument Road.

4. Description of PRBs Selected for Investigation

Siting criteria specified locating PRBs along roadways that are cross-gradient to the regional groundwater flow direction and relatively close to impacted embayments. Roadway settings are important for access and facilitate installation.

- **Duck Hole PRB:** The Duck Hole PRB extends north to south along Highview Lane, Old Duck Hole Road, and Lovells Lane with a length of approximately 4,100 feet. The planned PRB was estimated to extend 30 feet into the saturated zone and would reduce nitrogen loading from the Pochet Neck Watershed to Pochet Neck Stream. The full Duck Hole PRB is shown on Figure 2. North and south sections of the PRB are shown on Figure 3 and Figure 4, respectively. Green highlighted parcels in these figures are properties within the capture zone of the PRB and are sources of wastewater nitrogen load.
- **Briar Spring PRB:** Briar Spring PRB extends approximately 2,900 feet northeast to southwest along Briar Spring Road. The planned PRB was estimated to extend 30 feet into the groundwater saturated zone and would reduce nitrogen loading the Pleasant Bay Watershed in the vicinity of Pochet Inlet. The full Briar Spring PRB is shown on Figure 5. The north and south sections of the PRB are shown on Figure 6 and Figure 7, respectively.
- **Namequoit and Ridge PRBs**: Due to proximity the Namequoit and Ridge PRBs were evaluated together. The Namequoit PRB is located along Namequoit Road extending approximately 1,000 feet west from Little Marsh Lane. The Ridge PRB extends north to south on Ridgewood Road and is approximately 460 feet in length. The combined length for evaluation is 1,460 feet. Both PRBs would extend 30 feet into the saturated zone and would reduce nitrogen loading to the Namequoit River. The Namequoit and Ridge PRBs are shown on Figure 8 and Figure 9.

5. Investigation Objectives and Assessment Approach

The investigation was designed to determine the local hydrologic and water quality conditions at the potential PRB site gathering the following information:

A. Depth to groundwater at each location,

B. Direction and velocity of groundwater flow,

C. Soil stratigraphy and hydraulic conductivity in the target vertical extent of the PRB or profile,

D. Maximum feasible depth of direct push injection, and

E. Groundwater chemistry and nitrate concentration in the target profile.

This information was used to assess the feasibility of PRB installation, develop specifications for PRB design, and estimate the potential nitrogen load reduction in kilograms of nitrogen removed per year.

6. Summary of Field Investigations

The field investigation generally followed the methodology described in the U.S. Geological Survey report *Hydrologic site assessment for passive treatment of groundwater nitrogen with permeable reactive barriers*, *Cape Cod, Massachusetts* (Barbero, et al. 2019). The field investigation proceeded in a two phased approach to optimize data collection and included installation of deep soil borings and monitoring wells on the edge of public roadways.

The selected soil boring and monitoring well locations were spatially positioned to form a triangle at each PRB or within segments of each large PRB so that the local groundwater flow direction could be estimated with groundwater elevation surveys and triangulation.

Each triangulation of monitoring wells (i.e., DU-1-37. DU-2-26, DU-3-51, Figure 2) was designed to include a cluster of monitoring wells screened at up to three elevations: (1) shallow; (2) intermediate; and (3) deep with a maximum target installation depth of 100 feet below ground surface.

Soil boring logs were recorded for the deepest soil boring/monitoring well location to document subsurface soil characteristics. The triangulation of monitoring wells was located a sufficient distance apart to estimate the direction of groundwater flow and groundwater gradient based on relative water table elevations. Each soil boring/monitoring well location was identified and adjusted as necessary following field reconnaissance and subsurface utility location. All wells were constructed from two-inch diameter PVC riser and were completed with ten-foot screen intervals.

The first phase of investigation was completed in the Fall of 2021 and included installation of the deepest soil boring at each location, preparing and evaluating soil boring logs to define stratigraphy, soil sample collection to determine soil characteristics, and installing the deepest of the three planned monitoring wells (shallow, intermediate, and deep wells) at each location. Boring logs are included in Appendix C.

The installation of the deepest monitoring wells was followed by:

- Monitoring well elevation and location survey,
- Water level measurement,
- Field water quality parameter measurement, and
- Water quality sampling and analysis.

Deep Soil borings were completed using a Roto-Sonic drilling rig (Refer to **Figure C – Roto-Sonic Rig Completing Deep Soil Boring**) at 17 locations distributed across the 4 PRB locations. The Roto-Sonic drilling method produced high quality soil cores for observations of soil stratigraphy and can quickly penetrate to deeper depths. A Geoprobe direct push rig was also deployed to these soil boring locations to conduct penetration tests to verify the ability of the direct push rig to rapidly penetrate the subsurface soils up to 100 feet at each location. The direct push tests successfully verified the drilling methods ability to quickly drill and inject substrate during future PRB construction.



Figure C – Roto-Sonic Rig Completing Deep Soil Boring

The first phase of field work was followed by a period of data review and evaluation. The soil borings were reviewed to determine the vertical extent of soil suitable for PRB installation. Groundwater elevations were used to triangulate and estimate the direction of groundwater flow at the water table and verify the depth to groundwater. Groundwater monitoring and analytical results were used for an initial assessment of groundwater chemistry and nitrogen compound concentration.

The second phase of field investigation was completed in December 2021 and January 2022 and included installation of intermediate depth and shallow water table monitoring wells by the direct push method as necessary to complete each monitoring well location. This phase included additional groundwater gauging and sample collection.

The full set of monitoring wells in the completed network is as follows:

- **Duck Hole PRB**: 6 monitoring well clusters, with 3 monitoring wells in each cluster. Well identification code **DU - location number - depth of bottom of the 10-foot monitoring well screen** (e.g., BR-1-100),
- **Briar Spring PRB:** 6 clusters of monitoring wells with 3 wells at each location. Well identification code **BR - location number - depth of bottom of 10-foot screen**,
- **Namequoit PRB:** 2 clusters of monitoring well, one with 2 wells, one with 3 wells. Well identification code **NA - location number - depth of bottom of 10-foot screen**,
- **Ridge PRB:** 3 monitoring well clusters, one with 1 monitoring well, two with 2 wells. Well identification code **RI - location number - depth of bottom of 10-foot screen**.

A total of 17 monitoring well locations with a total of 46 monitoring wells were installed in the combined field efforts. Monitoring well construction details are included in Table 1. Each monitoring well was surveyed for location and top of casing elevation.

7. Groundwater Monitoring

Groundwater monitoring was conducted to test water quality and characterize groundwater geochemistry. The results of analyses provide data for a detailed evaluation of the feasibility of PRB installation, potential nitrogen load reduction, and PRB design.

Completed monitoring wells were sampled during two events including: (1) following installation November 2021 to February 2022; and (2) in May 2022. Depth to groundwater measurements were completed prior to groundwater sampling. Groundwater monitoring was conducted with peristaltic, or Whale submersible pump connected to a YSI meter with a flow through cell to measure field parameters. Groundwater samples were collected once field parameters stabilized on the water quality meter.

Monitoring events included:

- Groundwater elevation gauging
- Measurement of field groundwater parameters:
  - pH (SU)
  - Temperature (°C)
  - Dissolved Oxygen (DO, mg/L)
  - Redox Potential (ORP; mV)
  - Specific Conductivity (µS/cm)
  - Turbidity (NTU)
- Sample collection for laboratory analyses of:
  - Nitrate as N (mg/L)
  - Nitrite as N (mg/L)
  - Total Kjeldahl Nitrogen (TKN) (mg/L)
  - Total Nitrogen (mg/L)
  - Dissolved Organic Carbon (DOC)(mg/L)
  - Dissolved Iron (mg/L)
  - Dissolved Manganese (mg/L)

Laboratory samples were sent to ESS Laboratory for analysis.

8. Water Levels and Groundwater Flow

Measured groundwater elevations from three water table wells at each PRB or section of PRB were used to assess groundwater gradients and find the slope of the water table. Refer to **Figure D - Groundwater Gradient Illustration**. The groundwater gradient (i) was determined by finding the difference between upgradient and downgradient groundwater elevations and then dividing that difference by the distance between the monitoring wells. Groundwater flow direction was determined by evaluating water table elevations at the three points of each of triangle of monitoring wells.

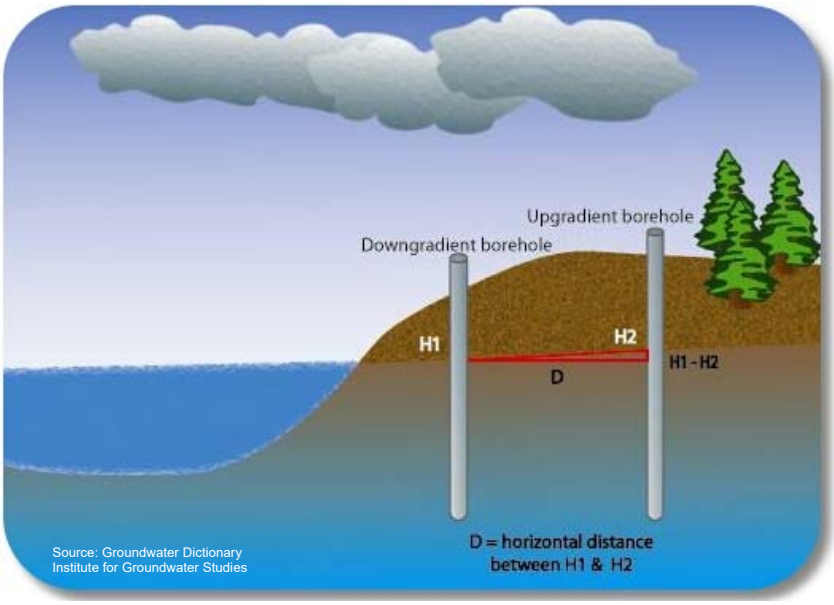


Figure D - Groundwater Gradient Illustration

Identified groundwater flow directions are included as blue arrows on PRB figures. Generally measured groundwater elevations and resulting groundwater flow directions matched the directions predicted by particle track modeling completed in the previous phase of PRB planning and supported the proposed orientations of PRBs. Groundwater gauging data and water table elevations/piezometric head levels for both sampling events are included in Table 2.

The groundwater velocity was calculated with the Darcy's Law equation:

V= ki/n where:

V = Groundwater velocity (ft/day)

K = hydraulic conductivity (ft/day)

i = groundwater gradient (unitless)

n = effective porosity of sand (unitless)

Soil samples were taken from continuous core samples collected during deep soil borings completed with the Roto-Sonic drilling rig. The subsurface materials were characterized to assess the variability of aquifer material for estimates of hydraulic conductivity. Based on the subsurface materials observed at each PRB a representative hydraulic conductivity for the sandy material was estimated at 150 feet/day.

9. Investigation Results

A summary of groundwater gradient, velocity, and flow directions determined in the assessment for each PRB is provided in **Table A – PRB Summary of Groundwater Gradient, Velocity, and Flow Directions**.

Table A – PRB Summary of Groundwater Gradient, Velocity, and Flow Directions

PRB Location	Groundwater Gradient (unitless)	Groundwater Velocity (feet/day)	Flow Direction
Duck Hole	0.001	0.5	East to Southeast
Briar Spring	0.001	0.5	Southeast
Namequoit/Ridge	0.001	0.5	Northeast

The groundwater velocity (0.5 feet per day) was found to be the same at each PRB location and is typical for groundwater velocity on Cape Cod. Vertical hydraulic gradients at well clusters were qualitatively assessed based on piezometric head measurements from the shallow, intermediate, and deep monitoring wells. Generally, this assessment showed flow was vertically upward, typical for locations near the coast where groundwater eventually discharges to surface water. Some locations had little vertical gradient and some indicated conflicting results, potentially associated with flow up or down to more permeable strata.

10. Hydrogeologic Assessment and Subsurface Geology

Investigation Objectives related to subsurface geology included:

- Depth to groundwater at each location,
- Direction and velocity of groundwater flow.
- Soil stratigraphy and hydraulic conductivity in the target profile,
- Maximum feasible depth of direct push injection and potential target PRB depth, and
- Findings for each PRB are presented below.

A. Duck Hole PRB

1) **Depth to Groundwater:** The water table was encountered at an elevation of approximately 3 feet of elevation (NAVD 88), 11 feet below ground surface at DU-2 and 37 feet below ground surface at DU-3 due to hilly topography.

2) **Groundwater Flow Direction:** Based on recorded water table elevations the groundwater flow direction at the Duck Hole PRB is to the southeast or east as shown with blue arrows on Figure 3 and Figure 4.

3) **Soil Stratigraphy:** Cross sections of the geologic strata were developed at two locations along the Duck Hole PRB. The location of geologic cross section line A to A' from monitoring location DU-3 to DU-2 is shown for the northern section of the PRB on Figure 3 and the cross-section is shown in Figure 10. Soil strata encountered in the saturated zone below the water table was found to be fine to coarse sand down to elevation -45 feet. Silty sand was encountered at approximate elevation -45 feet extending down to -55 feet with fine sand observed below from -55 feet to elevation -85 feet.

   Figure 4 shows the geologic cross section line B to B' for the southern section of the Duck Hole PRB between DU-5 and DU-6 and cross section B to B' is shown on Figure 11. Soil strata encountered in the saturated zone below the water table was found to be fine to coarse sand with a trace of gravel down to elevation -65 feet. Sand with a trace of silt and clay were found below the -65 feet elevation.

4) **Feasible Target PRB Depth:** Duck Hole subsurface material appears hydraulically suitable for PRB installation from the water table down to elevation -80 feet. Direct push tests indicated it took approximately 25 minutes for the Geoprobe Rig to push to 90 feet below ground surface at locations DU-2 (elevation -76 feet) and DU-5 (elevation -69 feet).

B. Briar Spring PRB

1) **Depth to Groundwater:** The water table was encountered at approximately 2 feet of elevation along Briar Springs Road and Gilman Lane. The depth to groundwater ranged from 21 feet at BR-2 to 42 feet below land surface at BR-3.

2) **Groundwater Flow Direction:** Based on recorded water table elevations the groundwater flow direction at the Briar Spring PRB was generally to the south southeast as shown with blue arrows on Figure 6 and Figure 7.

3) **Soil Stratigraphy:** Geologic cross section line C to C' is shown for the northern section of the Briar Spring PRB along Briar Spring Road between BR-2 to BR-3 on Figure 6 and the cross-section is shown in Figure 12. The southern section of the PRB on Gilman Lane is shown on Figure 7 along with the location of cross section D to D' between BR-5 and BR-6. Cross section D to D' is shown in Figure 13.

   Soil strata encountered in the saturated zone varies significantly along the Briar Spring PRB. The soil boring at BR-3 in the northern section along cross section C to C' encountered permeable fine to coarse sand from the water table elevation down to elevation -35 feet, where lower permeability sand and silt with some bands of clay were encountered. The sand with silt and clay extended down to elevation -50 where fine to coarse sand was encountered before the boring was terminated at elevation -57 feet (100 feet below land surface). At the far end of the C to C' cross section at BR-2, saturated zone soil was mainly fine to medium sand with some gravel with limited bands of fine sand with silt.

   Along the southern cross section D to D' soils were mainly fine to coarse sand with a trace of gravel and intermittent silty sand layers with some clay.

4) **Feasible Target PRB Depth:** Briar Spring PRB subsurface material appears hydraulically suitable for PRB installation from the water table down to elevation -70 feet. Direct push tests indicated it took 25 minutes for the Geoprobe Rig to push to 90 feet below ground surface at location BR-2 and 30 minutes to push to 80 feet below land surface at BR-5.

C. Namequoit PRB and Ridge PRB

1) **Groundwater Flow Direction:** The location of the Namequoit PRB and Ridge PRB is shown on Figure 8. Based on recorded water table elevations the groundwater flow direction at the Namequoit and Ridge PRB was generally to the northeast toward the Namequoit River as shown with blue arrows on Figure 9. A large topographically low wetland area east of Ridgewood Road may affect the direction of groundwater flow locally.

2) **Depth to Groundwater:** The land surface elevation varies widely in the vicinity of these PRBs. Surface elevation ranges from 11 feet at the eastern end of the Namequoit PRB at Little Marsh Lane up to 56 feet near the western end. The depth to groundwater ranges from 9 feet at NA-2 on the corner of Little Marsh Lane (groundwater elevation 5.3 feet) to approximately 46 feet below land surface on the western end of the Namequoit PRB near Heritage Drive. The depth to groundwater at the western end of the PRB on Namequoit Road was estimated based on land surface elevation and the 65-foot depth to groundwater at nearby monitoring location NA-1 on Heritage Drive (groundwater elevation 9.4 feet).

   Ridgewood Road located off Heritage Drive is also located in a hilly area. The depth to groundwater ranged from 28 feet below land surface at RI-2 (groundwater elevation 8 feet) to 61 feet below land surface at RI-3 (groundwater elevation 5.7 feet).

3) **Soil Stratigraphy:** Geologic cross section line E to E' runs between NA-1 on Heritage Drive extending approximately 1,100 feet east to NA-2 on Namequoit Road (see Figure 9 and Figure 14). The soil boring at NA-1 was terminated at elevation -25 feet due to the 65-foot depth to groundwater at this drilling location. Strata encountered in the saturated zone at NA-1 was mainly fine to coarse sand with a 3-foot layer of dense silt at elevation -14 to -17 (89 to 92 feet below land surface) with fine to coarse sand below. On the east end of cross section E to E' at NA-2, fine to coarse sand with a trace of gravel extended from the water table to approximately elevation -40 where fine sand and silt with thin bands of dense silt and clay were encountered.

   The Ridge PRB geologic cross section F to F' location between monitoring wells at RI-3 and RI-2 is shown on Figure 9 and the cross section is shown on Figure 15. Fine to coarse sand with a trace of gravel was found down to elevation -20 at R-3 and to -25 feet at RI-2. Fine sand with some silt was found below -25 feet down to elevation -65 feet.

4) **Feasible Target PRB Depth:** Subsurface material at the Namequoit and Ridge PRBs generally appear hydraulically suitable for PRB installation from the water table down to elevation -65 feet elevation. Direct push tests indicated it took 28 minutes for the Geoprobe Rig to push to 78 feet below ground surface (-64 feet elevation) at location NA-2 with penetration beyond 70 feet slower than shallower sections.

11. Assessment of Groundwater Chemistry

Investigation objectives also included data collection for evaluation of groundwater chemistry in the vicinity of proposed PRBs. This assessment included collecting nitrogen data for evaluation of flux and information related to groundwater Redox conditions that affect nitrogen chemistry.

Groundwater with sufficient dissolved oxygen (DO) for aerobic biological processes is considered oxic. Generally lower dissolved DO and oxidation-reduction potential (ORP) (low Redox conditions) or anoxic were observed in groundwater from the deeper monitoring wells compared to shallow monitoring wells. Groundwater is considered anoxic if the DO is < 1 mg/L or the ORP is less than +50 mV. Oxygen is often difficult to measure in groundwater with as oxygen can be increased while sampling. This evaluation was supported by a secondary line of evidence of that indicates anoxic conditions based on elevated dissolved iron and manganese levels. Iron and manganese are present in subsurface geologic material and are dissolved in groundwater at higher concentrations under low Redox conditions.

Observed anoxic conditions generally corresponded to low nitrate concentrations or non-detectable nitrate concentrations. Field parameters and laboratory results for each sampling event are included in Table 3. Charts showing the variation of oxygen and nitrate with depth at each monitoring location are included in Appendix D and laboratory reports are included in Appendix E.

A. Duck Hole PRB

1) **Redox Conditions:** A review of data collected for the Duck Hole PRB location indicated that one of six deep monitoring wells, DU-2-100, consistently showed anoxic groundwater conditions. One monitoring well DU-1-100, showed anoxic conditions in the first round of testing and aerobic conditions in the second round. The rest of the deep monitoring wells showed aerobic conditions with some being only marginally aerobic. Shallow and intermediate depth monitoring wells all showed aerobic groundwater conditions.

2) **Nitrogen Concentrations:** Groundwater nitrogen was mainly in the form of nitrate as indicated by similar concentrations of nitrate and total nitrogen. Concentrations of nitrate were not consistent between sampling rounds. The nitrate concentration decreased between the 1st and 2nd round at shallow monitoring well DU-6-33. Nitrate concentrations in Duck Hole deep monitoring wells increased at the second round in May 2022, with higher concentrations at all deep locations. The average and range of nitrate concentrations in Duck Hole monitoring wells are presented in **Table B – Duck Hole PRB - Summary of Nitrate Concentrations and Range at MW Depths**.

Table B – Duck Hole PRB - Summary of Nitrate Concentrations and Range at MW Depths

Sampling Round	MW Depth	Average Nitrate Concentration (mg/L)	Nitrate Concentration Range (mg/L)
First	Shallow	2.5	0.81 - 8.72
	Intermediate	2.08	0.78- 5.2
	Deep	0.68	0.11 - 1.12
Second	Shallow	1.91	0.25 - 4.15
	Intermediate	2.0	1.73 - 3.66
	Deep	1.68	0.23 - 3.46

B. Briar Spring PRB

1) **Redox Conditions:** At the Briar Spring PRB location five of six deep monitoring wells indicated groundwater conditions were anoxic. All shallow and intermediate monitoring wells showed aerobic conditions.

2) **Nitrogen Concentrations:** Groundwater nitrogen was mainly in the form of nitrate. Concentrations of nitrate were consistent between sampling rounds except for deep screen results for monitoring well BR-4-100, where the nitrate concentration increased in the second round in May 2022. The average concentration and range of nitrate concentrations in Briar Spring monitoring wells are presented in **Table C - Briar Spring PRB - Summary of Nitrate Concentrations and Range at MW Depths**.

Table C - Briar Spring PRB - Summary of Nitrate Concentrations and Range at MW Depths

Sampling Round	MW Depth	Average Nitrate Concentration (mg/L)	Nitrate Concentration Range (mg/L)
First	Shallow	0.97	0.44 - 1.09
	Intermediate	1.31	0.62 - 2.6
	Deep	0.18	0.03 - 0.16
Second	Shallow	0.88	0.44 - 1.35
	Intermediate	1.49	0.83 - 2.21
	Deep	0.37	0.03 - 1.79

C. Namequoit PRB and Ridge PRB

1) **Redox Conditions:** A review of data collected for the Namequoit PRB location indicated aerobic conditions at the NA-1 location at the two deepest monitoring wells installed (NA-1-78 and NA-1-98). Only two wells were installed at this location due to the significant depth to groundwater (approximately 64 feet). All three wells installed at the NA-2 location, including NA-2-22, NA-2-55, and NA-2-88 showed anoxic conditions. Data collected for the Ridge PRB location indicated anoxic conditions at the intermediate depth RI-2-58 monitoring well.

2) **Nitrogen Concentrations:** The concentration of nitrate was low, < 1 mg/L or not detected at Namequoit PRB monitoring wells except for NA-1-78 where 1.71 and 1.83 mg/L were detected in the 1st and 2nd sampling events respectively. Total nitrogen concentrations were less than 1 mg/L. Ridge PRB monitoring wells showed generally low concentrations with some variation higher or lower between sampling rounds. The average concentration and range of nitrate concentrations in Namequoit PRB and Ridge PRB monitoring wells are presented in **Table D - Namequoit PRB - Summary of Nitrate Concentrations and Range at MW Depths** and **Table E - Ridge PRB - Summary of Nitrate Concentrations and Range at MW Depths**.

Table D - Namequoit PRB - Summary of Nitrate Concentrations and Range at MW Depths

Sampling Round	MW Depth	Average Nitrate Concentration (mg/L)	Nitrate Concentration Range (mg/L)
First	Shallow	0.03	0.03
	Intermediate	0.87	0.03 - 1.71
	Deep	0.29	0.03 -0.55
Second	Shallow	0.03	0.03
	Intermediate	0.93	0.03 - 1.83
	Deep	0.38	0.03 - 0.74

Table E - Ridge PRB - Summary of Nitrate Concentrations and Range at MW Depths

Sampling Round	MW Depth	Average Nitrate Concentration (mg/L)	Nitrate Concentration Range (mg/L)
First	Shallow	1.34	1.34
	Intermediate	0.75	0.36 - 1.14
	Deep	0.47	0..45-0.49
Second	Shallow	1.13	1.13
	Intermediate	0.47	0.45 - 0.48
	Deep	1.01	0.43- 1.58

12. PRB Nitrate Flux Evaluation

An evaluation of nitrate mass flux was used to compare the nitrate flux estimated in the previous phase of work based on wastewater source characterization to a mass flux determined with concentration and groundwater flow data from this investigation.

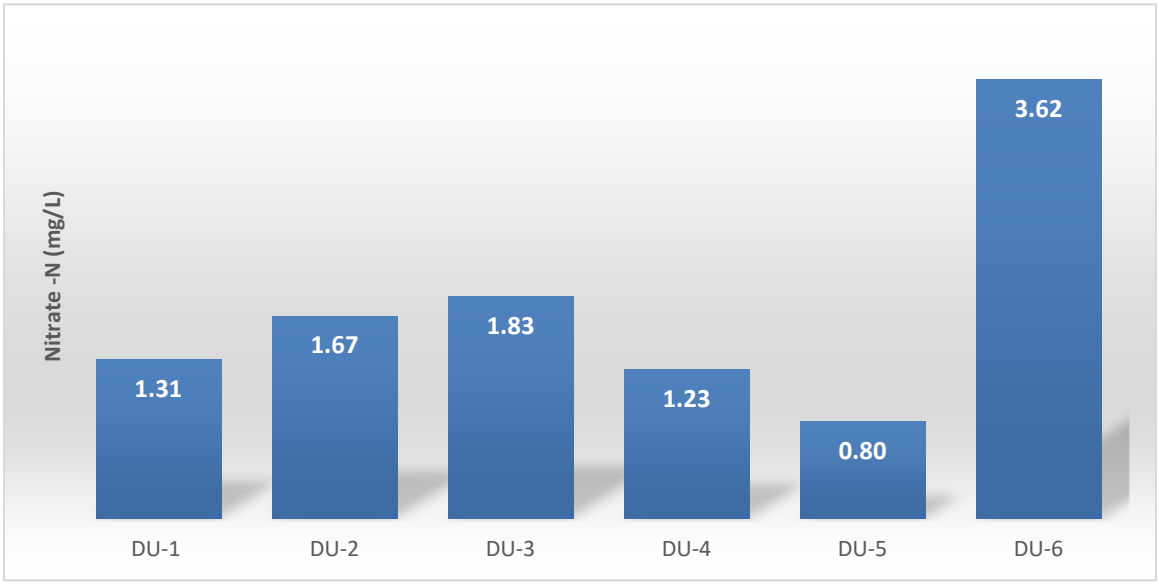
The source characterization method was reported in the Final Technical Memorandum: Permeable Reactive Barriers (PRB) Full-Scale Watershed Planning (AECOM 2021) included in Appendix A. The density of septic system wastewater nitrogen sources was assessed by estimating the number of parcels within the capture zone or area of groundwater intercepted by the PRBs assuming the PRBs would extend down 30 feet into the saturated zone. The associated nitrogen load generated in that area was calculated with specified assumptions including water use and source strength characteristics used by the MEP in estimating nitrogen loading to the estuary. For planning purposes PRBs were assumed to remove 80 percent of the nitrogen load as groundwater passes through.

In the current effort a nitrate flux estimate was developed from collected groundwater data and observed hydrogeologic conditions. Estimating nitrogen flux with a limited data set constrains the development of a flux estimate with a high confidence level but provides for a rough estimate or a range of potential flux. The nitrate data from each monitoring location (e.g., DU-1) was used to assess the range of nitrogen concentration for flux estimates. Nitrate concentration data from available shallow, intermediate, and deep monitoring wells, including data from both rounds of sampling were vertically averaged for each monitoring well cluster. This provided a representative concentration for the assessed groundwater vertical profile at the location. The location with the lowest and highest representative concentration were then used, along with site specific groundwater velocity estimates to calculate the range of nitrate flux for each PRB. The flux calculation used a 30-foot vertical extent of PRB to match the 30-foot extent of the PRB used to calculate the flux based on source strength. The actual potential flux and nitrogen reduction by the PRB will depend on the installed depth and may be greater than the flux used for comparison to the source strength estimate (see conclusions section). The results are presented for each PRB below.

A. Duck Hole PRB Nitrate Flux Evaluation

The range of average nitrate concentrations at Duck Hole monitoring locations was 0.80 mg/L to 3.62 mg/L as seen in **Figure E – Duck Hole PRB Average Nitrate Concentrations**. Four of the six monitoring locations had an average between 1 and 2 mg/L of nitrate. The highest average concentration was observed at location DU-6 where the shallow monitoring well showed a significantly higher concentration in the first round of testing than the subsequent round.

Figure E – Duck Hole PRB Average Nitrate Concentrations



A nitrate flux range was calculated using the low and high average concentrations, a groundwater velocity of 0.5 feet/day, PRB dimensions of 4,100 feet of length, and a 30-foot vertical treatment zone to match the assumed 30-foot PRB used for the source load estimate. The vertical profile of monitoring data varied from location to location due to site specific variables including depth to groundwater, soil characteristics, and depth of the monitoring wells. The resulting nitrate flux range is compared to the estimated flux based on the modeled septic system load for the capture zone is presented in **Table F - Duck Hole PRB Flux Range**.

Table F - Duck Hole PRB Flux Range

Description	Nitrate (mg/L)	Nitrate Flux (kg/yr.)
Low Concentration	0.80	178
High Concentration	3.62	805
Estimated sewer load based on source strength	---	370

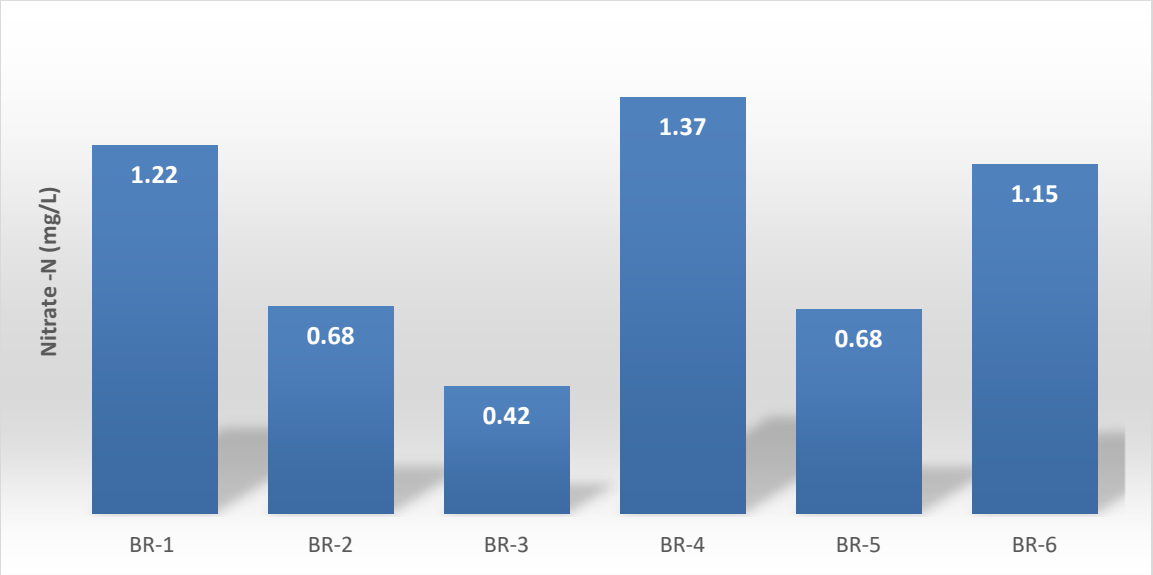
Note: Assumes a 30-foot vertical extent of the PRB.

The estimated nitrogen load based on wastewater source strength falls within the range of observed vertically averaged nitrate concentration.

B. Briar Spring PRB Nitrate Flux Evaluation

The range of average nitrate concentrations at Briar Spring monitoring locations was 0.42 mg/L to 1.37 mg/L as seen in **Figure F – Briar Spring PRB Average Nitrate Concentrations**.

Figure F – Briar Spring PRB Average Nitrate Concentrations



The nitrate flux range was calculated using the low and high average concentrations, a groundwater velocity of 0.5 feet/day, PRB dimensions of 2,900 feet of length, and a 30-foot vertical treatment zone. The resulting nitrate flux range is compared to the estimated flux based on the septic system load from the capture zone is presented in

Table G - Briar Spring PRB Flux Range.

Table G - Briar Spring PRB Flux Range

Description	Nitrate (mg/L)	Nitrate Flux (kg/yr.)
Low Concentration	0.42	66
High Concentration	1.37	216
Estimated sewer load based on source strength	---	321

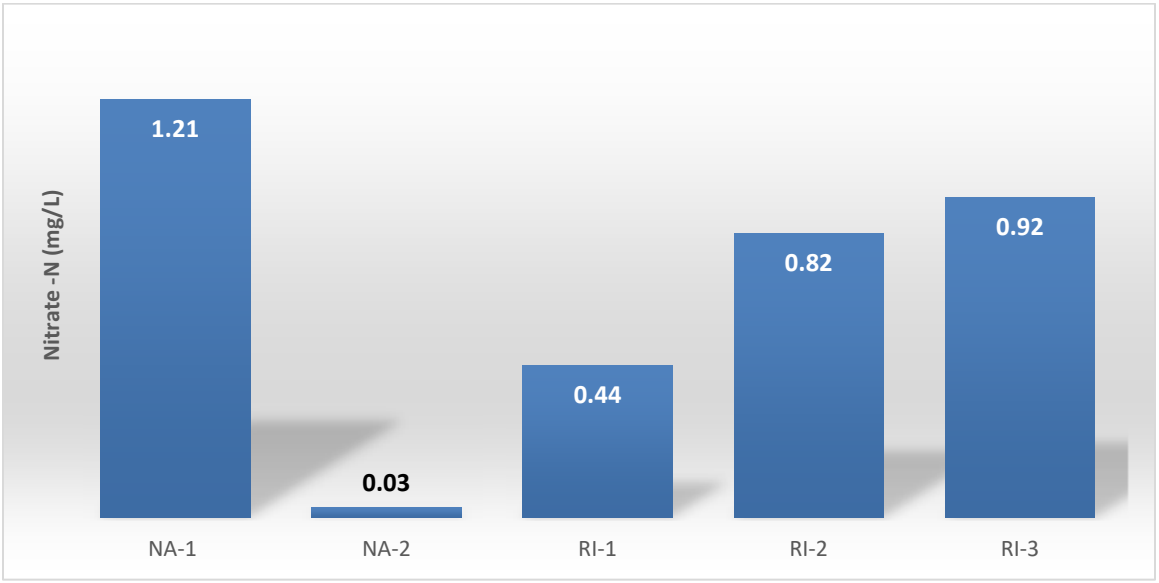
Note: Assumes a 30-foot vertical extent of the PRB.

The estimated nitrogen load based on wastewater source strength is approximately 50 percent higher than the load at the high end of the observed vertically averaged nitrate concentration.

C. Namequoit PRB and Ridge PRB Nitrate Flux Evaluation

The range of average nitrate concentrations for the combined Namequoit and Ridge PRB monitoring locations was from 0.03 mg/L (the detection limit) to 1.21 mg/L as seen in **Figure G – Namequoit PRB and Ridge PRB Average Nitrate** Concentrations.

Figure G – Namequoit PRB and Ridge PRB Average Nitrate Concentrations



The nitrate flux range was calculated using the low and high average concentrations, a groundwater velocity of 0.5 feet/day, a combined PRB length of 1,460 feet, and a 30-foot vertical treatment zone. The resulting nitrate flux range is compared to the estimated flux based on the septic system load from the capture zones is presented in

Table H - Combined Namequoit PRB and Ridge PRB Flux Range.

Table H - Combined Namequoit PRB and Ridge PRB Flux Range

Description	Nitrate (mg/L)	Nitrate Flux (kg/yr.)
Low Concentration	0.03	2
High Concentration	1.21	96
Estimated Sewer Load Namequoit PRB	---	147
Estimated Sewer Load Ridge PRB	---	158
Total Estimated Sewer Load	---	305

Note: Assumes a 30-foot vertical extent of the PRB.

The total estimated nitrogen load based on wastewater source strength is 220 percent higher than the load at the high end of the range based on observed vertically averaged nitrate concentration.

13. Discussion and Conclusions

The number of monitoring wells installed and completion of two sampling events limits the evaluation of nitrate concentration, groundwater flow, and nitrate flux at the assessed locations. The nature and distribution of septic system wastewater sources and the groundwater recharge and transport system conceptually suggests nitrate plumes arising from wastewater discharge will be narrow, undergo limited mixing and potentially have intermittent (seasonal) source strength. Groundwater flow direction may also vary seasonally or in response to changing climatic conditions. However, the investigation results provide a snapshot of existing conditions and sufficient data to achieve project objectives.

A. Observed Groundwater Conditions and Nitrate Flux

In general, groundwater nitrate concentrations were lower than expected. Groundwater chemistry and redox conditions varied between sampling locations. Anoxic conditions were noted in groundwater samples at 11 of the 46 monitoring wells, most being deep monitoring wells. All monitoring wells that showed local anoxic conditions had nitrate concentrations less than 1 mg/L. This observation suggests that denitrification may be occurring naturally under anoxic conditions. Naturally occurring biologically mediated denitrification has been identified by multiple investigators in aquifers including on Cape Cod. Travel time in groundwater from source to discharge is a key factor in the degree of denitrification (Coleman et al. 2004).

Naturally occurring denitrification may be responsible for lower observed nitrogen flux compared to the estimated nitrogen flux based on nitrogen sources. Lower concentrations and anoxic conditions noted in several deep monitoring wells may indicate loss of nitrate from upgradient sources due to long travel times to monitoring locations. Based on this observation, deeper zones in the aquifer may be less beneficial targets for installation of PRBs due to lower nitrate flux associated with naturally occurring denitrification. Deeper zones are also less favorable for PRB installation due to increased costs and the limited feasibility of injecting substrate into deep zones.

B. Feasibility of Implementing PRB Locations and Potential PRB Dimensions

1) Duck Hole PRB (83')

Duck Hole lithologic conditions appear hydraulically suitable for PRB installation from the water table (elevation +3 feet) down to elevation -80 feet (83 feet total) and this depth can be reached in a reasonable period of time (less than 30 minutes drilling) based on penetration tests. The depth to groundwater varies along the PRB and some areas and the vicinity of Wind Swept Lane at a higher land surface elevation that may preclude installation to the maximum depth.

Nitrate was present at concentrations greater than 1 mg/L in at least one of the two sampling rounds at shallow, intermediate, and deep locations. The depth of the PRB would not be limited by the nitrate profile.

Recalculating nitrate flux for the Duck Hole PRB assuming a length of 4,100 feet and a vertical extent of 83 feet provides and a potential range of nitrogen flux from 492 to 2,228 kg/year. Assuming an 80 percent reduction in nitrate flux based on potential PRB performance gives a nitrate load removal between 394 kg/yr. and 1,782 kg/yr.

This location is recommended for further consideration of full-scale PRB installation.

2) Briar Spring PRB

Briar Spring lithologic conditions appear hydraulically suitable for PRB installation from the water table (elevation 2 feet) down to elevation -70 feet (72 feet total) and this depth can likely be reached in a reasonable period of time based on penetration tests. Some locations along the path of the PRB are at higher topographic elevation that may reduce the target depth below land surface.

The nitrate concentration was low or non-detect and conditions were anoxic at 5 of the 6 deep Briar Spring monitoring wells. Based on these data a PRB at this location would not extend deeper than observed nitrate concentrations greater than 1 mg/l at intermediate depth wells. Based on nitrate concentration limitations the proposed PRB would have a vertical extent from elevation from 2 to – 40 feet.

Recalculating nitrate flux for the Briar Spring PRB assuming a length of 2,900 feet and a vertical extent of 42 feet provides and potential range of nitrogen flux from 93 to 302 kg/year. Assuming an 80 percent reduction in nitrate flux based on potential PRB performance gives a nitrate load removal between 74 kg/yr. and 242 kg/yr.

This location is recommended for further consideration of full-scale PRB installation.

3) Namequoit PRB and Ridge PRB

Namequoit and Ridge lithologic conditions were observed to be more complex than other PRB locations. The shallower saturated zone was permeable fine to coarse sand while intermediate and deeper zones included lower permeability silty sand, and silt and clay lenses. The depth to groundwater was significant at several monitoring locations including NA-2 and RI-3 and would limit the extent of potential PRBs.

The nitrate concentration was low at most monitoring locations. The only monitoring wells with nitrate exceeding 1 mg/L in both rounds of testing were NA-1-78 and RI-2-44. Monitoring well location NA-2 showed anoxic conditions and non-detect levels of nitrate at shallow, intermediate, and deep monitoring wells. This may be associated with the extensive wetlands nearby where natural denitrification may be occurring. This wetland area may also be influencing the local groundwater flow direction. Based on both geologic conditions and nitrate concentrations the Namequoit PRB and Ridge PRB are not suitable candidate locations for PRBs.

This location is not recommended for further consideration of full-scale PRB installation.

14. References

AECOM 2021, Memorandum: Permeable Reactive Barriers (PRB) Full-Scale Watershed Planning

Barbaro, J.R., Belaval, M., Truslow, D.B., LeBlanc, D.R., Cambareri, T.C., and Michaud, S.C., 2019, Hydrologic site assessment for passive treatment of groundwater nitrogen with permeable reactive barriers, Cape Cod, Massachusetts: U.S. Geological Survey Scientific Investigations Report 2019–5047, 39 p., https://doi.org/10.3133/sir20195047

Colman, J.A., Masterson, J.P., Wendy J. Pabich, W.J. and Walter, J. A., 2004, Effects of Aquifer Travel Time on Nitrogen Transport to a Coastal Embayment. Ground Water (Vol. 42, Issue 7.)

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Tables

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Table 1 Orleans Monitoring Well Construction Details

Well ID	TOC Elevation (ft)	Total Well Depth (ft bgs)	Screen Beginning Depth (ft bgs)	Screen End Depth (ft bgs)	Top Screen Elevation (ft)	Bottom Screen Elevation (ft)	Mid-Screen Elevation (ft)	Screen Length (ft)	Inst. Date	Location
DU-1-100	25.31	99.15	90.0	100.0	-64.69	-74.69	-69.69	10.0	9/21/21	Countryside Ln
DU-1-68	24.93	66.65	58.0	68.0	-33.07	-43.07	-38.07	10.0	11/17/21	Countryside Ln
DU-1-37	24.74	36.65	22.0	37.0	2.74	-12.26	-4.76	15.0	11/17/21	Countryside Ln
DU-2-100	14.69	101.50	90.0	100.0	-75.31	-85.31	-80.31	10.0	9/20/21	Countryside Ln
DU-2-63	14.68	61.10	53.0	63.0	-38.32	-48.32	-43.32	10.0	11/17/21	Countryside Ln
DU-2-26	14.50	25.50	11.0	26.0	3.50	-11.50	-4.00	15.0	11/17/21	Countryside Ln
DU-3-100	39.60	99.58	90.0	100.0	-50.40	-60.40	-55.40	10.0	9/21/21	Windswept Ln
DU-3-76	39.47	75.40	66.0	76.0	-26.53	-36.53	-31.53	10.0	11/17/21	Windswept Ln
DU-3-51	39.70	51.00	36.0	51.0	3.70	-11.30	-3.80	15.0	11/17/21	Windswept Ln
DU-4-100	40.64	100.12	90.0	100.0	-49.36	-59.36	-54.36	10.0	9/22/21	Old Duck Hole Rd
DU-4-76	40.66	75.40	66.0	76.0	-25.34	-35.34	-30.34	10.0	11/15/21	Old Duck Hole Rd
DU-4-52	39.88	48.20	37.0	52.0	2.88	-12.12	-4.62	15.0	11/16/21	Old Duck Hole Rd
DU-5-100	22.25	100.00	90.0	100.0	-67.75	-77.75	-72.75	10.0	9/23/21	Old Duck Hole Rd
DU-5-67	21.97	66.40	57.0	67.0	-35.03	-45.03	-40.03	10.0	11/16/21	Old Duck Hole Rd
DU-5-34	21.50	33.65	19.0	34.0	2.50	-12.50	-5.00	15.0	11/16/21	Old Duck Hole Rd
DU-6-100	21.38	100.00	90.0	100.0	-68.62	-78.62	-73.62	10.0	9/23/21	Old Duck Hole Rd
DU-6-67	21.24	67.00	57.0	67.0	-35.76	-45.76	-40.76	10.0	11/16/21	Old Duck Hole Rd
DU-6-33	21.40	33.00	18.0	33.0	3.40	-11.60	-4.10	15.0	11/16/21	Old Duck Hole Rd
BR-1-98	43.10	97.75	88.0	98.0	-44.90	-54.90	-49.90	10.0	9/17/21	Dale Ann Dr
BR-1-77	43.02	77.00	67.0	77.0	-23.98	-33.98	-28.98	10.0	11/18/21	Dale Ann Dr
BR-1-55	42.81	55.00	40.0	55.0	2.81	-12.19	-4.69	15.0	11/18/21	Dale Ann Dr
BR-2-96	23.11	96.00	86.0	96.0	-62.89	-72.89	-67.89	10.0	9/17/21	Briar Springs Ln
BR-2-66	22.86	66.00	56.0	66.0	-33.14	-43.14	-38.14	10.0	11/18/21	Briar Springs Ln
BR-2-36	22.96	36.00	21.0	36.0	1.96	-13.04	-5.54	15.0	11/18/21	Briar Springs Ln
BR-3-100	44.56	102.00	90.0	100.0	-45.44	-55.44	-50.44	10.0	10/7/21	Briar Springs Ln
BR-3-80	44.63	80.00	70.0	80.0	-25.37	-35.37	-30.37	10.0	11/18/21	Briar Springs Ln
BR-3-60	44.52	60.95	50.0	60.0	-5.48	-15.48	-10.48	10.0	9/15/21	Briar Springs Ln
BR-4-100	56.21	100.00	90.0	100.0	-33.79	-43.79	-38.79	10.0	10/6/21	Briar Springs Ln
BR-4-84	56.26	84.00	74.0	84.0	-17.74	-27.74	-22.74	10.0	11/19/21	Briar Springs Ln
BR-4-68	56.32	68.00	53.0	68.0	3.32	-11.68	-4.18	15.0	11/19/21	Briar Springs Ln
BR-5-90	25.88	89.90	80.0	90.0	-54.12	-64.12	-59.12	10.0	10/2/21	Gilman Ln
BR-5-64	25.96	63.35	54.0	64.0	-28.04	-38.04	-33.04	10.0	11/19/21	Gilman Ln
BR-5-37	25.69	37.00	22.0	37.0	3.69	-11.31	-3.81	15.0	11/19/21	Gilman Ln

Table 1 Orleans Monitoring Well Construction Details

Well ID	TOC Elevation (ft)	Total Well Depth (ft bgs)	Screen Beginning Depth (ft bgs)	Screen End Depth (ft bgs)	Top Screen Elevation (ft)	Bottom Screen Elevation (ft)	Mid-Screen Elevation (ft)	Screen Length (ft)	Inst. Date	Location
BR-6-100	44.25	100.00	90.0	100.0	-45.75	-55.75	-50.75	10.0	9/20/21	Briar Springs Ln
BR-6-78	44.56	77.43	68.0	78.0	-23.44	-33.44	-28.44	10.0	11/22/21	Briar Springs Ln
BR-6-56	43.26	56.00	41.0	56.0	2.26	-12.74	-5.24	15.0	11/22/21	Briar Springs Ln
NA-1-92	74.29	92.00	82.0	92.0	-7.71	-17.71	-12.71	10.0	9/30/21	Namequoit Rd
NA-1-78	74.23	78.00	63.0	78.0	11.23	-3.77	3.73	15.0	11/22/21	Namequoit Rd
NA-2-88	14.22	88.00	78.0	88.0	-63.78	-73.78	-68.78	10.0	10/1/21	Little Marsh Ln
NA-2-55	14.35	55.00	45.0	55.0	-30.65	-40.65	-35.65	10.0	11/22/21	Little Marsh Ln
NA-2-22	14.35	22.00	7.0	22.0	7.35	-7.65	-0.15	15.0	11/22/21	Little Marsh Ln
RI-1-105	95.86	106.78	95.0	105.0	0.86	-9.14	-4.14	10.0	9/30/21	Highwood Rd
RI-2-58	36.57	58.95	48.0	58.0	-11.43	-21.43	-16.43	10.0	9/25/21	Ridgegwood Rd
RI-2-44	36.70	44.00	28.0	44.0	8.70	-7.30	0.70	16.0	11/22/21	Ridgegwood Rd
RI-3-90	67.65	90.00	80.0	90.0	-12.35	-22.35	-17.35	10.0	9/29/21	Ridgegwood Rd
RI-3-77	66.81	77.00	61.0	77.0	5.81	-10.19	-2.19	16.0	11/19/2021	Ridgegwood Rd

Notes:

N/A = Not Available

Table 2 Orleans Groundwater Elevations

Well ID	Location	Date	TOC Elevation (ft)	Depth to Water (ft)	GW Elevation (ft)
DU-1-100	Countryside Ln	11/4/2021	25.31	21.58	3.73
DU-1-68	Countryside Ln	12/21/2021	24.93		
DU-1-37	Countryside Ln	1/25/2022	24.74	21.45	3.29
DU-2-100	Countryside Ln	11/4/2021	14.69	11.16	3.53
DU-2-63	Countryside Ln	12/22/2021	14.68	11.62	3.06
DU-2-26	Countryside Ln	12/22/2021	14.50	11.50	3.00
DU-3-100	Windswept Ln	11/4/2021	39.60	36.03	3.57
DU-3-76	Windswept Ln	12/22/2021	39.47	36.52	2.95
DU-3-51	Windswept Ln	12/22/2021	39.70	36.71	2.99
DU-4-100	Old Duck Hole Rd	11/4/2021	40.64	37.17	3.47
DU-4-76	Old Duck Hole Rd	12/22/2021	40.66	37.80	2.86
DU-4-52	Old Duck Hole Rd	12/22/2021	39.88	37.20	2.68
DU-5-100	Old Duck Hole Rd	11/4/2021	22.25	18.83	3.42
DU-5-67	Old Duck Hole Rd	12/22/2021	21.97	19.05	2.92
DU-5-34	Old Duck Hole Rd	12/22/2021	21.50	18.70	2.80
DU-6-100	Old Duck Hole Rd	11/4/2021	21.38	18.29	3.09
DU-6-67	Old Duck Hole Rd	1/24/2022	21.24	18.52	2.72
DU-6-33	Old Duck Hole Rd	1/25/2022	21.40	18.65	2.75
BR-1-98	Dale Ann Dr	11/3/2021	43.10	40.15	2.95
BR-1-77	Dale Ann Dr	1/27/2022	43.02	40.67	2.35
BR-1-55	Dale Ann Dr	1/27/2022	42.81	40.42	2.39
BR-2-96	Briar Springs Ln	11/3/2021	23.11	21.40	1.71
BR-2-66	Briar Springs Ln	1/27/2022	22.86	20.73	2.13
BR-2-36	Briar Springs Ln	1/27/2022	22.96	20.73	2.23
BR-3-100	Briar Springs Ln	11/3/2021	44.56	41.63	2.93
BR-3-80	Briar Springs Ln	1/27/2022	44.63	42.15	2.48
BR-3-60	Briar Springs Ln	11/3/2021	44.52	41.54	2.98
BR-3-60	Briar Springs Ln	1/27/2022	44.52	42.31	2.21

Table 2 Orleans Groundwater Elevations

Well ID	Location	Date	TOC Elevation (ft)	Depth to Water (ft)	GW Elevation (ft)
BR-4-100	Briar Springs Ln	11/3/2021	56.21	53.31	2.90
BR-4-84	Briar Springs Ln	2/3/2022	56.26	53.75	2.51
BR-4-68	Briar Springs Ln	2/3/2022	56.32	53.75	2.57
BR-5-90	Gilman Ln	11/3/2021	25.88	23.20	2.68
BR-5-64	Gilman Ln	2/3/2022	25.96	23.82	2.14
BR-5-37	Gilman Ln	2/3/2022	25.69	23.61	2.08
BR-6-100	Briar Springs Ln	11/3/2021	44.25	41.40	2.85
BR-6-78	Briar Springs Ln	12/21/2021	44.56	43.20	1.36
BR-6-56	Briar Springs Ln	1/27/2022	43.26	41.00	2.26
NA-1-92	Heritage Drive	11/2/2021	74.29	63.40	10.89
NA-1-78	Heritage Drive	1/26/2022	74.23	64.80	9.43
NA-2-88	Little Marsh Ln	11/3/2021	14.22	7.33	6.89
NA-2-55	Little Marsh Ln	2/3/2022	14.35	8.00	6.35
NA-2-22	Little Marsh Ln	2/3/2022	14.35	9.03	5.32
RI-1-105	Highwood Rd	11/2/2021	95.86	86.24	9.62
RI-2-58	Ridgegwood Rd	11/2/2021	36.57	28.55	8.02
RI-2-44	Ridgegwood Rd	1/26/2022	36.70	28.49	8.21
RI-3-90	Ridgegwood Rd	11/2/2021	67.65	61.78	5.87
RI-3-77	Ridgegwood Rd	2/3/2022	66.81	61.11	5.70

Notes:

N/A = Not Available

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**DU-1-100**		**DU-1-68**		**DU-1-37**		**DU-2-100**		**DU-2-63**		**DU-2-26**		**DU-3-100**	
Top of Screen Elevation (ft)	-64.69		-33.07		2.74		-75.31		-38.32		3.50		-50.40	
Bottom of Screen Elevation (ft)	-74.69		-43.07		-12.26		-85.31		-48.32		-11.50		-60.40	
Sampling Date	11/4/2021	5/10/2022	12/21/2021	5/10/2022	1/25/2022	5/10/2022	11/4/2021	5/10/2022	12/22/2021	5/10/2022	12/22/2021	5/10/2022	11/4/2021	5/10/2022
Type of Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample
Field Measurements														
pH (SU)	7.32	5.78	6.62	5.64	5.33	4.93	6.67	5.99	6.44	6.07	6.08	5.62	6.24	6.26
Temperature (^{o}C)	12.30	12.20	11.90	12.30	12.85	12.30	12.32	12.10	11.90	12.00	13.75	11.20	13.0	12.9
Dissolved Oxygen (DO, mg/L)	2.08	7.71	5.72	8.88	6.76	8.38	0.70	2.09	6.62	7.43	3.87	5.02	3.06	5.58
Redox Potential (ORP; mV)	-108.00	18.00	96.60	191.90	-31.60	280.00	-9.10	-37.70	139.50	130.00	156.70	4.30	190.5	157.8
Specific Conductivity (µS/cm)[c]	208.80	263.30	258.40	310.30	184.00	162.40	364.00	337.50	203.10	172.00	661.00	460.40	200.7	299.0
Turbidity (NTU)	9.87	4.15	7.29	5.05	168.00	18.94	2.36	7.04	10.70	20.13	42.70	9.46	32.80	13.89
Laboratory Analyses														
Nitrogen														
Nitrate as N (mg/L)	**0.985**	**3.46**	**0.782**	**1.56**	**0.813**	**0.246**	**0.158**	**0.654**	**1.19**	**1.18**	**2.69**	**4.15**	**1.12**	**2.68**
Nitrite as N (mg/L)	**0.168**	<0.01	-	<0.01	-	<0.01	0.01	<0.01	-	<0.01	-	<0.01	**0.064**	<0.01
Total Kjeldahl Nitrogen (TKN) (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Nitrogen (mg/L)	**1.15**	**3.69**	**1.09**	**1.56**	**1.21**	**0.483**	0.2	**0.654**	1.21	**1.43**	3.43	**4.65**	**1.19**	**2.68**
Other														
DOC (mg/L)	**-**	**0.588**	**-**	**1.05**	**-**	**2.13**	**-**	**0.554**	**-**	**0.794**	**-**	**5.23**	**-**	**0.974**
Elements														
Dissolved Iron (mg/L)	**0.595**	<0.1	**<0.1**	<0.1	0.1	<0.1	**2.48**	**1.09**	0.1	<0.1	**0.107**	<0.1	**0.521**	<0.1
Dissolved Manganese (mg/L)	**1.2**	**0.199**	**0.769**	**0.088**	**0.025**	**0.038**	**1.08**	**0.433**	**0.174**	**0.049**	**<0.02**	<0.02	**0.215**	**0.043**

Notes:

NS - Not Sampled

Bold - detected above the Minimum Detection Limit

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**DU-3-76**		**DU-3-51**		**DU-4-100**		**DU-4-76**		**DU-4-52**		**DU-5-100**		**DU-5-67**	
Top of Screen Elevation (ft)	-26.53		3.70		-49.36		-25.34		2.88		-67.75		-35.03	
Bottom of Screen Elevation (ft)	-36.53		-11.30		-59.36		-35.34		-12.12		-77.75		-45.03	
Sampling Date	12/22/2021	5/10/2022	12/22/2021	5/10/2022	11/4/2021	5/11/2022	12/22/2021	5/11/2022	12/22/2021	5/11/2022	11/4/2021	5/13/2022	12/22/2021	5/13/2022
Type of Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample
Field Measurements														
pH (SU)	6.13	5.59	6.28	5.37	7.41	5.94	6.54	5.93	6.05	5.67	6.42	5.90	6.30	5.81
Temperature (^{o}C)	12.9	13.5	13.0	14.3	11.8	11.8	11.5	11.8	11.5	12.3	11.5	11.6	11.4	11.8
Dissolved Oxygen (DO, mg/L)	5.66	7.30	6.49	6.53	3.81	6.70	5.68	7.82	8.59	8.64	1.79	4.63	8.29	9.43
Redox Potential (ORP; mV)	138.2	184.4	159.0	194.1	146.5	164.3	61.4	127.7	149.4	186.1	30.5	-12.8	133.5	213.4
Specific Conductivity (µS/cm)[c]	611.0	479.1	555.0	569.0	149.9	174.8	271.7	228.2	946.0	387.7	175.0	157.5	352.5	255.5
Turbidity (NTU)	14.80	104.54	10.40	19.88	5.25	3.00	10.90	6.28	124.00	10.40	0.02	13.86	25.80	4.41
Laboratory Analyses														
Nitrogen														
Nitrate as N (mg/L)	**2.56**	**2.81**	**0.821**	**0.99**	**0.621**	**1.58**	**1.32**	**1.73**	**0.81**	**1.32**	**0.106**	**0.232**	**1.45**	**1.04**
Nitrite as N (mg/L)	-	<0.01	-	<0.01	**0.053**	<0.01	-	<0.01	-	<0.01	0.01	<0.01	-	<0.01
Total Kjeldahl Nitrogen (TKN) (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Nitrogen (mg/L)	**2.57**	**3.72**	**1.07**	**1.3**	**0.674**	**1.58**	**1.35**	**1.73**	**0.824**	**1.32**	0.2	**0.581**	1.73	**1.82**
Other														
DOC (mg/L)	**1.37**	**1.16**	**-**	**1.83**	**-**	**0.896**	**-**	**0.926**	**-**	**0.896**	**-**	**0.776**	**-**	**1.04**
Elements														
Dissolved Iron (mg/L)	**0.308**	**0.143**	0.1	<0.1	0.1	<0.1	0.798	<0.1	<0.1	<0.1	**0.798**	<0.1	**0.128**	<0.1
Dissolved Manganese (mg/L)	**0.492**	**0.087**	**0.101**	<0.02	**0.315**	**0.166**	**0.399**	**0.113**	**0.151**	**0.02**	**0.556**	**0.041**	**0.048**	<0.02

Notes:

NS - Not Sampled

Bold - detected above the Minimum Detection Limit

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**DU-5-34**		**DU-6-100**		**DU-6-67**		**DU-6-33**		**BR-1-98**		**BR-1-77**		**BR-1-55**	
Top of Screen Elevation (ft)	2.50		-68.62		-35.76		3.40		-44.90		-23.98		2.81	
Bottom of Screen Elevation (ft)	-12.50		-78.62		-45.76		-11.60		-54.90		-33.98		-12.19	
Sampling Date	12/22/2021	5/13/2022	11/4/2021	5/13/2022	1/24/2022	5/13/2022	1/25/2022	5/13/2022	11/3/2021	5/12/2022	1/27/2022	5/12/2022	1/27/2022	5/12/2022
Type of Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample
Field Measurements														
pH (SU)	5.97	5.80	6.28	5.79	6.28	5.54	5.61	5.10	6.56	5.98	5.71	5.43	5.90	5.29
Temperature (^{o}C)	12.5	11.7	12.23	14.80	12.29	12.50	14.88	13.40	11.70	12.10	11.80	12.40	12.60	12.90
Dissolved Oxygen (DO, mg/L)	9.17	9.20	6.64	7.66	6.54	7.52	7.60	8.75	0.09	0.36	3.70	3.65	10.86	8.29
Redox Potential (ORP; mV)	188.7	29.9	112.60	32.10	-122.20	229.60	111.90	47.90	44.30	-58.10	16.70	205.10	185.10	264.30
Specific Conductivity (µS/cm)[c]	332.0	250.1	283.00	282.10	284.00	292.80	640.00	1228.00	149.90	204.60	243.00	207.20	361.00	770.00
Turbidity (NTU)	4.06	28.62	732.00	46.38	168.00	2.52	5.82	3.62	1.09	12.21	6.98	22.16	6.80	2.28
Laboratory Analyses														
Nitrogen														
Nitrate as N (mg/L)	**1.13**	**0.83**	**1.09**	**1.45**	**5.2**	**3.66**	**8.72**	**1.61**	**0.162**	**0.293**	**1.31**	**1.99**	**0.806**	**0.758**
Nitrite as N (mg/L)	-	<0.01	**0.019**	<0.01	-	<0.01	-	<0.01	0.01	<0.010	-	<0.010	-	<0.010
Total Kjeldahl Nitrogen (TKN) (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Nitrogen (mg/L)	1.13	**1.16**	**1.11**	**1.45**	**5.8**	**3.66**	**8.72**	**1.61**	0.2	**0.293**	1.31	**1.99**	0.806	**0.758**
Other														
DOC (mg/L)	**-**	**1.41**	**-**	**1.14**	**-**	**1.17**	**-**	**1.18**	**-**	**1.32**	1.47	**1.24**	**-**	**0.855**
Elements														
Dissolved Iron (mg/L)	0.1	<0.1	0.1	<0.1	**0.456**	<0.1	0.1	<0.1	**0.701**	<0.100	**0.155**	<0.100	**<0.1**	<0.100
Dissolved Manganese (mg/L)	**0.035**	**0.028**	**0.755**	**0.05**	**0.08**	<0.02	**0.091**	**0.11**	**0.506**	**0.055**	**0.068**	**0.037**	**0.025**	**0.034**

Notes:

NS - Not Sampled

Bold - detected above the Minimum Detection Limit

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**BR-2-96**		**BR-2-66**		**BR-2-36**		**BR-3-100**		**BR-3-80**		**BR-3-60**		
Top of Screen Elevation (ft)	-62.89		-33.14		1.96		-45.44		-25.37		-5.48		
Bottom of Screen Elevation (ft)	-72.89		-43.14		-13.04		-55.44		-35.37		-15.48		
Sampling Date	11/3/2021	5/12/2022	1/27/2022	5/12/2022	1/27/2022	5/12/2022	11/3/2021	5/12/2022	1/27/2022	5/12/2022	11/3/2021	1/27/2022	5/12/2022
Type of Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample
Field Measurements													
pH (SU)	6.53	7.09	5.87	5.54	5.77	5.85	7.32	6.38	6.03	5.77	6.45	5.91	5.65
Temperature (^{o}C)	12.0	11.9	11.6	12.4	12.1	13.0	12.0	11.9	11.9	12.1	12.3	12.1	12.4
Dissolved Oxygen (DO, mg/L)	0.32	0.12	8.51	6.81	9.76	8.76	0.21	0.14	6.92	5.57	7.08	7.30	7.31
Redox Potential (ORP; mV)	-79.9	-99.9	177.2	206.5	130.2	15.7	-73.7	-70.1	190.0	158.1	83.8	106.5	29.8
Specific Conductivity (µS/cm)[c]	6631.0	11700.0	215.0	249.6	263.0	413.7	398.0	443.1	355.0	395.0	364.0	372.0	367.5
Turbidity (NTU)	4.30	8.72	27.20	1.11	5.67	14.63	102.00	8.50	6.21	5.57	0.02	2.63	4.75
Laboratory Analyses													
Nitrogen													
Nitrate as N (mg/L)	0.03	<0.03	0.807	**0.827**	1.06	**1.35**	0.03	<0.0300	0.62	**0.654**	**0.566**	**0.646**	**0.631**
Nitrite as N (mg/L)	0.01	<0.010	-	<0.010	-	<0.010	0.01	**0.012**	-	<0.010	0.01	-	<0.010
Total Kjeldahl Nitrogen (TKN) (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Nitrogen (mg/L)	**1.09**	**1.5**	**0.807**	**0.827**	**1.06**	**1.35**	**0.325**	**0.815**	**0.62**	**0.963**	**0.566**	**0.861**	**0.947**
Other													
DOC (mg/L)	-	**1.49**	-	**0.897**	-	**1.24**	-	**1.2**	-	**1.12**	-	-	**6.19**
Elements													
Dissolved Iron (mg/L)	**3.28**	**3.92**	**0.15**	<0.100	**<0.1**	<0.100	**0.904**	**6.03**	**<0.1**	<0.100	**0.151**	**0.465**	**0.241**
Dissolved Manganese (mg/L)	**0.368**	**0.225**	**0.053**	<0.020	**<0.02**	<0.020	**0.349**	**1.51**	**0.152**	**0.022**	**0.043**	**<0.02**	<0.020

Notes:

NS - Not Sampled

Bold - detected above the Minimum Detection Limit

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**BR-4-100**		**BR-4-84**		**BR-4-68**		**BR-5-90**		**BR-5-64**		**BR-5-37**		**BR-6-100**	
Top of Screen Elevation (ft)	-33.79		-17.74		3.32		-54.12		-28.04		3.69		-45.75	
Bottom of Screen Elevation (ft)	-43.79		-27.74		-11.68		-64.12		-38.04		-11.31		-55.75	
Sampling Date	11/3/2021	5/19/2022	2/3/2022	5/19/2022	2/3/2022	5/19/2022	11/3/2021	5/18/2022	2/3/2022	5/18/2022	2/3/2022	5/18/2022	11/3/2021	5/12/2022
Type of Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample
Field Measurements														
pH (SU)	6.74	5.89	6.15	5.70	6.14	5.91	6.53	6.21	6.17	5.86	6.00	5.87	6.77	6.26
Temperature (^{o}C)	11.7	11.8	11.7	11.8	12.3	11.8	11.5	12.1	11.4	11.7	13.4	13.2	11.4	11.7
Dissolved Oxygen (DO, mg/L)	4.56	5.78	9.71	8.45	8.19	7.84	0.02	0.09	10.91	7.66	4.64	NA	0.35	0.14
Redox Potential (ORP; mV)	24.1	6.0	113.8	36.3	116.7	140.5	-317.7	-115.0	180.9	175.5	108.5	21.4	23.7	-108.0
Specific Conductivity (µS/cm)[c]	204.0	204.5	172.0	215.7	410.0	385.7	607.9	1218.0	230.0	216.9	1490.0	1561.0	176.0	176.0
Turbidity (NTU)	47.40	12.20	22.10	29.07	34.80	13.19	1.26	2.12	16.70	14.50	5.31	8.39	0.38	22.64
Laboratory Analyses														
Nitrogen														
Nitrate as N (mg/L)	**0.804**	**1.79**	**2.6**	**2.18**	**0.435**	**0.44**	0.03	<0.03	**1.09**	**1.1**	**1.07**	**0.731**	0.03	<0.0300
Nitrite as N (mg/L)	**0.046**	<0.01	-	<0.01	-	<0.01	0.01	<0.01	-	**0.011**	-	<0.01	0.01	<0.010
Total Kjeldahl Nitrogen (TKN) (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Nitrogen (mg/L)	**0.851**	**1.79**	**2.62**	**2.18**	**0.824**	**0.643**	**0.247**	<0.2	**1.45**	**1.11**	**1.43**	**1.08**	**0.412**	**0.405**
Other														
DOC (mg/L)	**-**	**1.06**	**-**	**0.928**	**-**	**1.9**	**-**	**1.05**	**-**	**0.938**	**-**	**3.47**	**-**	**1.38**
Elements														
Dissolved Iron (mg/L)	0.1	<0.1	**0.181**	**0.141**	**0.223**	<0.1	**3.71**	**3.28**	**0.133**	<0.1	<0.1	<0.1	**1.37**	**3.89**
Dissolved Manganese (mg/L)	**0.332**	**0.21**	**0.183**	**0.084**	**0.045**	**0.118**	**0.843**	**0.49**	**0.044**	<0.02	**0.449**	**0.075**	**0.401**	**0.194**

Notes:

NS - Not Sampled

Bold - detected above the Minimum Detection Limit

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**BR-6-78**		**BR-6-56**		**NA-1-92**		**NA-1-78**		**NA-2-88**		**NA-2-55**		**NA-2-22**	
Top of Screen Elevation (ft)	-23.44		2.26		-7.71		11.23		-63.78		-30.65		7.35	
Bottom of Screen Elevation (ft)	-33.44		-12.74		-17.71		-3.77		-73.78		-40.65		-7.65	
Sampling Date	12/21/2021	5/18/2022	1/27/2022	5/18/2022	11/2/2021	5/9/2022	1/26/2022	5/9/2022	11/3/2021	5/19/2022	2/3/2022	5/20/2022	2/3/2022	5/20/2022
Type of Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample
Field Measurements														
pH (SU)	6.23	5.74	6.20	6.13	6.06	5.62	5.77	5.53	7.18	6.73	7.19	6.83	5.56	5.21
Temperature (^{o}C)	11.1	12.4	11.4	13.6	11.8	11.5	11.5	11.9	11.1	10.4	10.1	11.4	10.1	10.6
Dissolved Oxygen (DO, mg/L)	3.36	5.80	8.81	8.73	5.75	8.33	9.59	9.68	0.17	0.29	0.02	0.18	0.29	0.51
Redox Potential (ORP; mV)	99.0	24.8	22,8	136.90	66.7	192.1	-22.3	37.7	-25.0	-85.6	-501.6	-120.6	-509.3	34.1
Specific Conductivity (µS/cm)[c]	224.6	247.6	200.0	227.3	449.0	475.6	260.0	802.7	136.0	124.5	91.0	102.6	111.0	168.0
Turbidity (NTU)	10.90	61.51	7.24	42.41	7.59	22.66	7.75	4.69	102.00	16.95	736.00	133.66	7.75	73.03
Laboratory Analyses														
Nitrogen														
Nitrate as N (mg/L)	1.45	**2.21**	1.86	**1.34**	**0.552**	**0.739**	**1.71**	**1.83**	0.03	<0.03	<0.03	<0.0300	<0.03	<0.0300
Nitrite as N (mg/L)	-	<0.01	-	<0.01	**0.017**	<0.01	-	<0.01	0.01	**0.011**	-	<0.010	-	**0.011**
Total Kjeldahl Nitrogen (TKN) (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Nitrogen (mg/L)	1.45	**2.21**	**2.11**	**1.34**	**0.774**	**1.39**	**1.93**	**1.83**	**0.33**	<0.2	**0.695**	**0.203**	**0.758**	**0.597**
Other														
DOC (mg/L)	-	**0.889**	-	**1.03**	-	**0.648**	-	**0.65**	-	**0.91**	**1**	**0.523**	-	**11**
Elements														
Dissolved Iron (mg/L)	**0.347**	<0.1	**<0.1**	**0.119**	**0.117**	<0.1	0.1	<0.1	**0.695**	**0.927**	**1.17**	**0.837**	**3**	**4.01**
Dissolved Manganese (mg/L)	**0.274**	**0.027**	**<0.02**	<0.02	**0.207**	<0.02	0.02	<0.02	**0.445**	**0.523**	**1.38**	**1.56**	**0.096**	**0.117**

Notes:

NS - Not Sampled

Bold - detected above the Minimum Detection Limit

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**RI-1-105**		**RI-2-58**		**RI-2-44**		**RI-3-90**		**RI-3-77**	
Top of Screen Elevation (ft)	0.86		-11.43		8.70		-12.35		5.81	
Bottom of Screen Elevation (ft)	-9.14		-21.43		-7.30		-22.35		-10.19	
Sampling Date	11/2/2021	5/13/2022	11/3/2021	5/9/2022	1/26/2022	5/9/2022	11/2/2021	5/9/2022	2/3/2022	5/9/2022
Type of Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample
Field Measurements										
pH (SU)	6.00	5.94	7.00	5.77	5.68	5.24	6.06	5.14	5.70	5.11
Temperature (^{o}C)	11.6	12.7	11.8	12.1	11.9	11.9	11.61	12.30	11.42	12.30
Dissolved Oxygen (DO, mg/L)	10.81	10.04	0.24	5.34	3.78	6.33	7.61	9.00	9.11	9.07
Redox Potential (ORP; mV)	90.4	53.5	-390.4	2.6	-15.6	215.6	38.60	48.00	118.10	255.50
Specific Conductivity (µS/cm)[c]	333.0	345.8	279.0	3.6	500.0	806.0	515.00	1247.00	164.00	711.00
Turbidity (NTU)	0.23	12.96	800.00	115.63	8.10	9.59	0.59	4.25	9.80	5.26
Laboratory Analyses										
Nitrogen										
Nitrate as N (mg/L)	**0.449**	**0.431**	**0.36**	**0.451**	**1.34**	**1.13**	**0.494**	**1.58**	**1.14**	**0.481**
Nitrite as N (mg/L)	0.01	<0.01	**0.366**	<0.01	-	<0.01	0.01	<0.01	-	<0.01
Total Kjeldahl Nitrogen (TKN) (mg/L)	-	-	-	-	-	-	-	-	-	-
Total Nitrogen (mg/L)	**0.449**	**0.431**	**1.42**	**0.882**	**1.34**	**1.67**	**0.494**	**1.58**	**1.34**	**0.481**
Other										
DOC (mg/L)	**-**	**0.965**	**-**	**0.751**	**-**	<0.5	**-**	**0.69**	**-**	**0.776**
Elements										
Dissolved Iron (mg/L)	0.1	<0.1	0.1	**2.16**	0.1	<0.1	**2.19**	**0.157**	<0.1	<0.1
Dissolved Manganese (mg/L)	**0.13**	<0.02	**1.23**	**0.419**	0.02	**0.028**	**0.443**	**0.105**	**0.058**	**0.065**

Notes:

NS - Not Sampled

Bold - detected above the Minimum Detection Limit

Figures

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Rock Harbor
Norseman
Tonset
Duck Hole
Blossom
Gosnold
Briar Spring
Keziahs
Monument
Mayflower
Namequoit
Ridge
Lockwood
Richwood
Grannys
Quonset
Quonset
Winslow

EASTHAM
BREWSTER
HARWICH
Orleans
East Orleans
South Orleans
Weeset
Tonset
Nauset Heights
Town Cove
Cedar Pond
Mill Pond
Crystal Lake
The River
Pilgrim Lake
Baker Pond
Meeting House Pond
Little Pleasant Bay
Pleasant Bay
Sampson Island
Hog Island
Sipson Island
Pochet Island Marshes
Rock Harbor Rd
Mid-Cape Hwy
Cranberry Hwy
Old Colony Way
Namskaket Rd
Main St
Route 6
Route 28
Route 6A

FIGURE 1

POTENTIAL PRB LOCATIONS

Legend

- Permeable Reactive Barrier
- Capture Zone Flow Paths
- Investigated PRBs

0 1,000 2,000 Feet

1 inch = 2,000 feet

AECOM

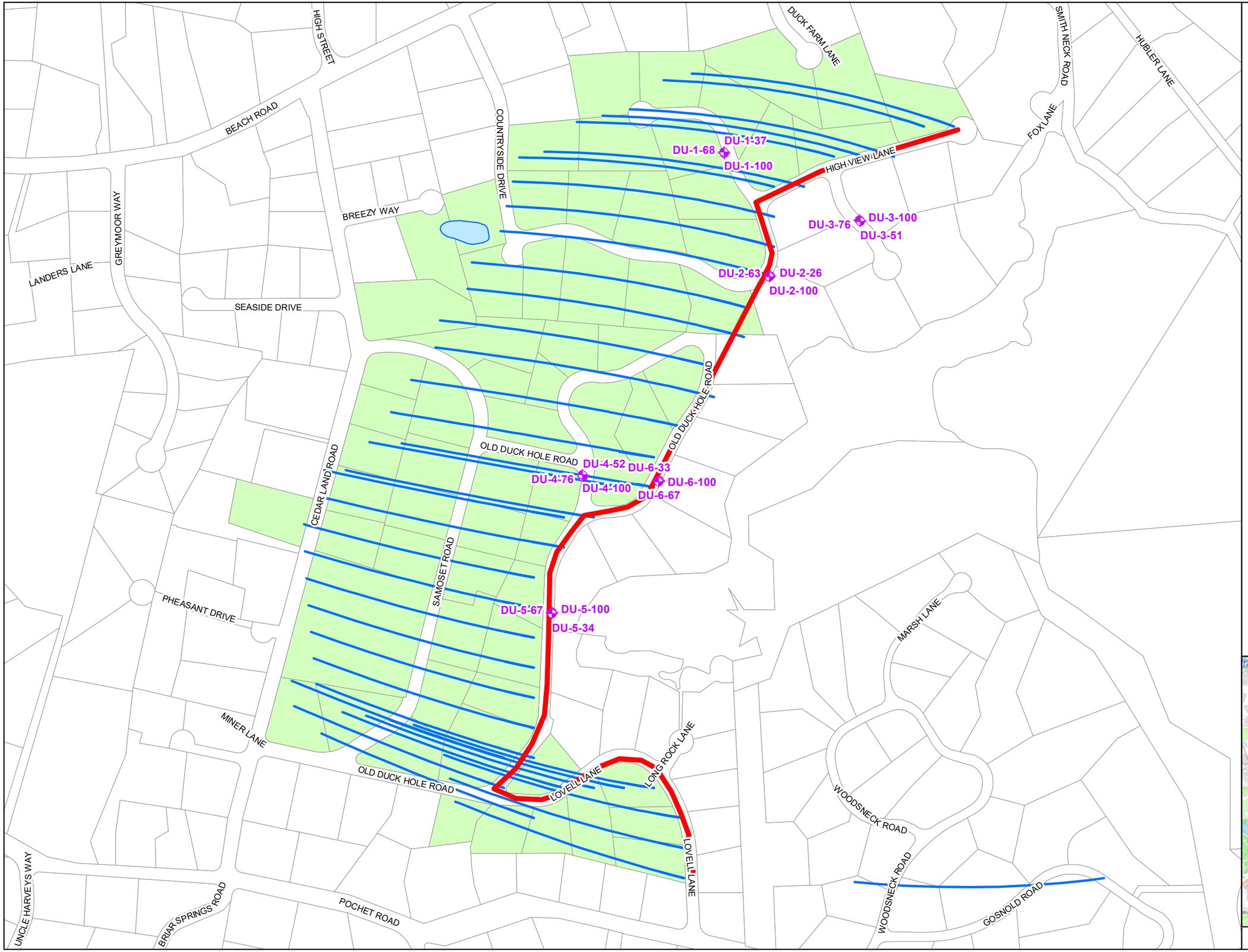
Date: 10/13/2022

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREM (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) Op Community

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FIGURE 2

DUCK HOLE PRB



Legend

- PRB Monitoring Well
- Permeable Reactive Barrier
- Capture Zone Flow Paths
- Parcel Upgradient of PRB
- Parcel Boundary

0 150 300 Feet

1 inch = 300 feet

AECOM

Date: 8/22/2022



Locator Map

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FIGURE 3

DUCK HOLE 01

DUCK FARM LANE

HIGH VIEW LANE

WINDSWEPT LANE

COUNTRYSIDE DRIVE

OLD DUCK HOLE ROAD

DU-1-68
DU-1-100
DU-1-37

DU-3-100
DU-3-51
DU-3-76
A'

DU-2-100
DU-2-26
DU-2-63
A

Legend

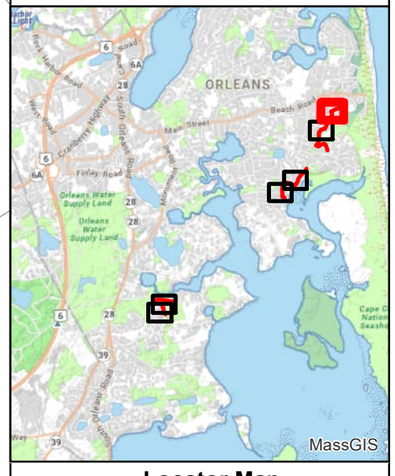
- PRB Monitoring Well
- Approximate Groundwater Flow Direction
- Permeable Reactive Barrier
- Cross-Section
- Parcel Upgradient of PRB

0 50 100 Feet

1 inch = 100 feet

AECOM

Date: 8/22/2022



Locator Map

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FIGURE 4

DUCK HOLE 02

OLD DUCK HOLE ROAD

OLD DUCK HOLE ROAD

OLD DUCK HOLE ROAD

SAMOSET ROAD

DU-4-76
DU-4-52
DU-4-100

DU-6-67
DU-6-100
DU-6-33

B'

DU-5-34
DU-5-100
DU-5-67

B

Legend

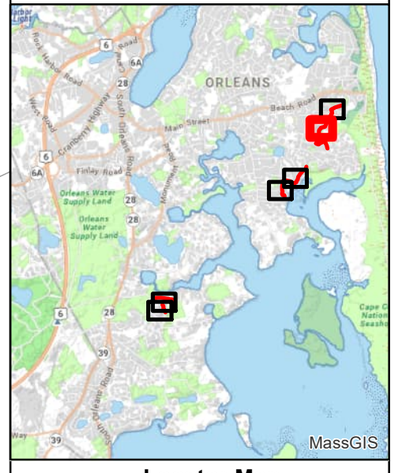
- PRB Monitoring Well
- Approximate Groundwater Flow Direction
- Permeable Reactive Barrier
- Cross-Section
- Parcel Upgradient of PRB

0 50 100 Feet

1 inch = 100 feet

AECOM

Date: 8/22/2022



Locator Map

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FIGURE 5

BRIAR SPRING PRB

HARVEYS LANE
FISHER WAY
SEA MIST DRIVE
BARLEY NECK ROAD
FOX RIDGE DRIVE
CARRIAGE PLACE
TWISS ROAD
GILMAN LANE
PLEASANT VIEW DRIVE
DALE ANN DRIVE
UNCLE HARVEYS WAY
BRIAR SPRINGS ROAD
SHORE VIEW DRIVE
SPARROWHAWK ROAD
SIBSIE LANE
BLOSSOM LANE

Uncle Harveys Pond

BR-3-100
BR-3-80
BR-3-60
BR-1-98
BR-1-55
BR-1-77
BR-2-66
BR-2-96
BR-2-36
BR-6-56
BR-6-78
BR-6-100
BR-4-68
BR-4-84
BR-4-100
BR-5-64
BR-5-90
BR-5-37

Legend

- PRB Monitoring Well
- Permeable Reactive Barrier
- Capture Zone Flow Paths
- Parcel Upgradient of PRB
- Parcel Boundary

0 125 250 Feet

1 inch = 250 feet

N

AECOM

Date: 8/22/2022



Locator Map

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FIGURE 6

BRIAR SPRING 01

DALE ANN DRIVE

FOX RIDGE DRIVE

FOX RIDGE DRIVE

DALE ANN DRIVE

SHORE VIEW DRIVE

BRIAR SPRINGS ROAD

BR-1-98

BR-1-77

BR-1-55

C'

BR-3-80

BR-3-100

BR-3-60

BR-2-96

BR-2-36

BR-2-66

C

Legend

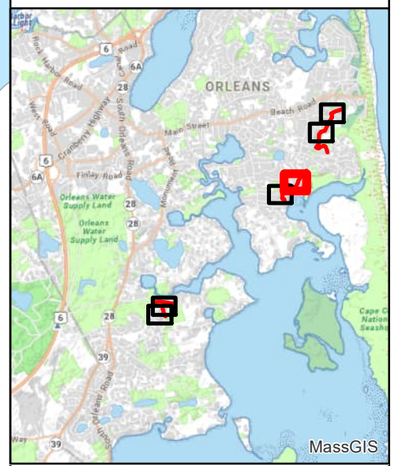
- PRB Monitoring Well
- Approximate Groundwater Flow Direction
- Permeable Reactive Barrier
- Cross-Section
- Parcel Upgradient of PRB

0 50 100 Feet

1 inch = 100 feet

AECOM

Date: 8/22/2022

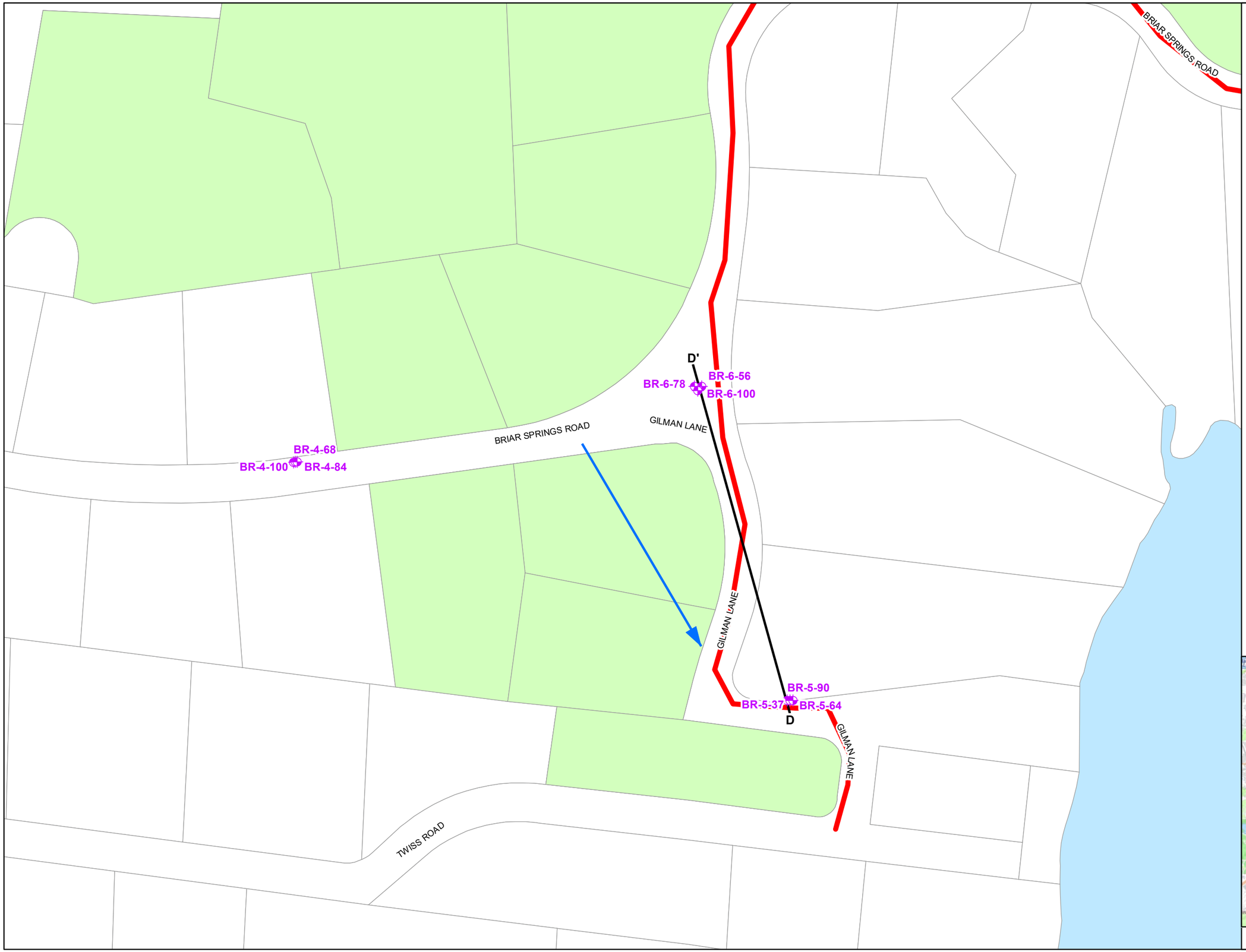


Locator Map

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FIGURE 7

BRIAR SPRING 02



Legend

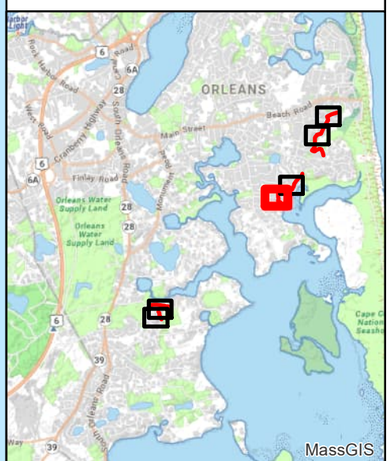
- PRB Monitoring Well
- Approximate Groundwater Flow Direction
- Permeable Reactive Barrier
- Cross-Section
- Parcel Upgradient of PRB

0 50 100 Feet

1 inch = 100 feet

AECOM

Date: 8/22/2022



Locator Map

C:\Work\60476644ORL\Maps\SelectedPRBs_detail.mxd

FIGURE 8

NAMEQUOIT/RIDGE PRB

SOUTH ORLEANS ROAD
WINDJAMMER WAY
NAMEQUOIT ROAD
LITTLE MARSH LANE
NA-2-88
NA-2-22
NA-2-55
NA-1-78
NA-1-92
RI-3-90
RI-3-77
WINDSOR LANE
RIDGEWOOD ROAD
RI-2-44
RI-2-58
RI-1-105
HIGHWOOD ROAD
PILGRIM DRIVE
STURBRIDGE DRIVE
HERITAGE DRIVE
COLONIAL DRIVE
JOHN KENRICK ROAD
CAROLINES WAY
LINDSAY LANE
PORTANIMICUT ROAD
RICHWOOD FARM LANE
INDIAN FORT HILL LANE

Legend

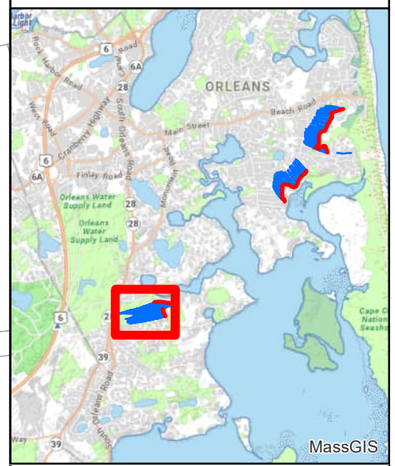
- PRB Monitoring Well
- Permeable Reactive Barrier
- Capture Zone Flow Paths
- Parcel Upgradient of PRB
- Parcel Boundary

0 125 250 Feet

1 inch = 250 feet

AECOM

Date: 8/22/2022



Locator Map

C:\Work\60476644\ORL\Maps\SelectedPRBs_full.mxd

FIGURE 9

NAMEQUOIT/RIDGE

NAMEQUOIT ROAD

LITTLE MARSH LANE

WINDSOR LANE

HERITAGE DRIVE

RIDGEWOOD ROAD

HIGHWOOD ROAD

NA-1-92

NA-1-78

E

E'

NA-2-22

NA-2-88

NA-2-55

F

RI-3-90

RI-3-77

RI-2-58

RI-2-44

F'

RI-1-105

Legend

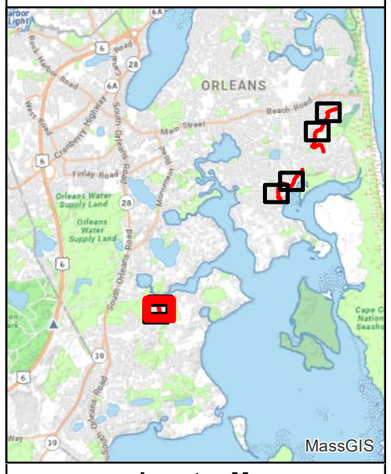
- PRB Monitoring Well
- Approximate Groundwater Flow Direction
- Permeable Reactive Barrier
- Cross-Section
- Parcel Upgradient of PRB

0 50 100 Feet

1 inch = 100 feet

AECOM

Date: 10/28/2022

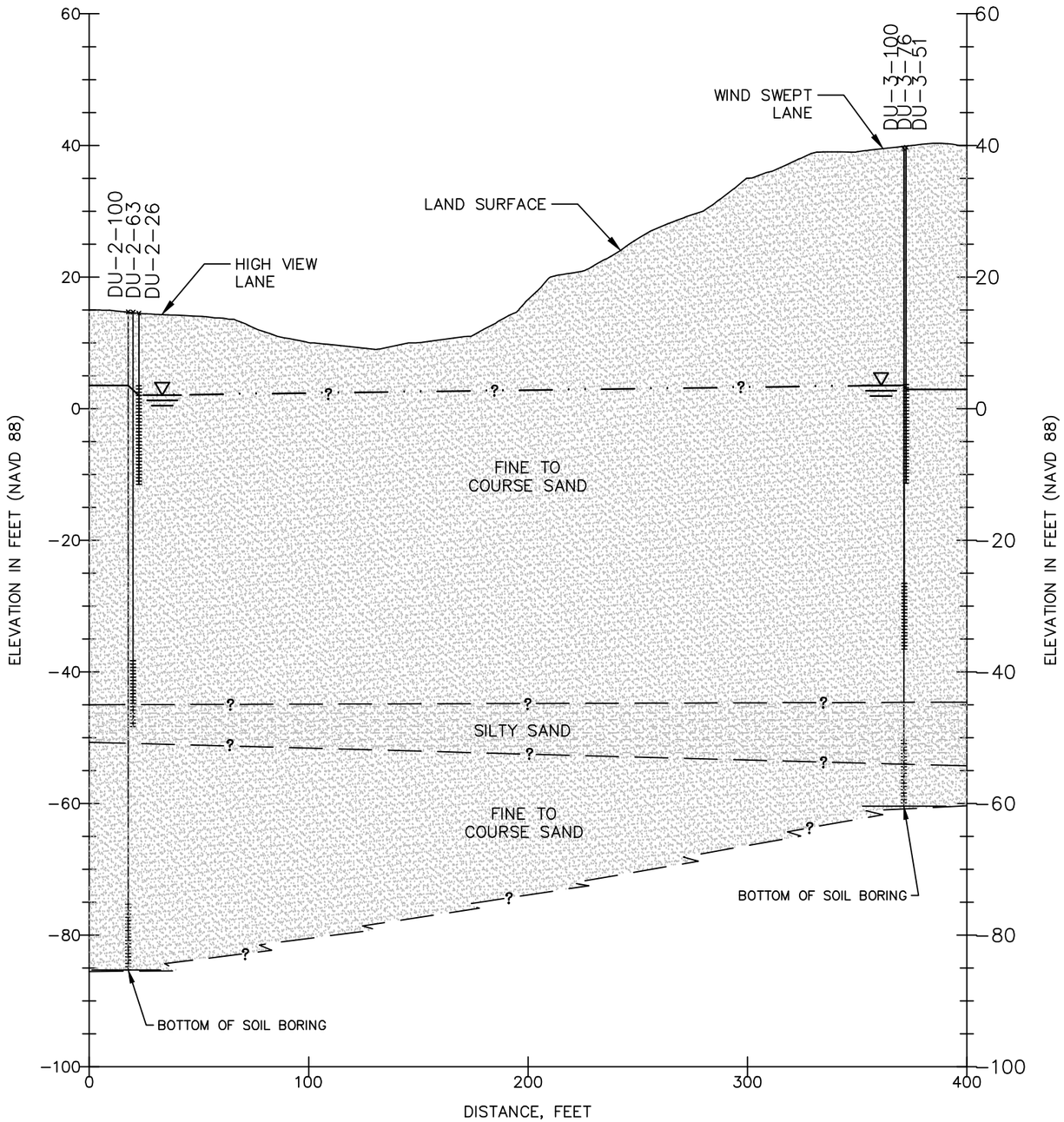


Locator Map

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A (SOUTHWEST)

A' (NORTHEAST)



LEGEND

SAND
SILTY SAND
SILT AND CLAY
SAND AND GRAVEL
SILT
GROUNDWATER SURFACE
WATER TABLE

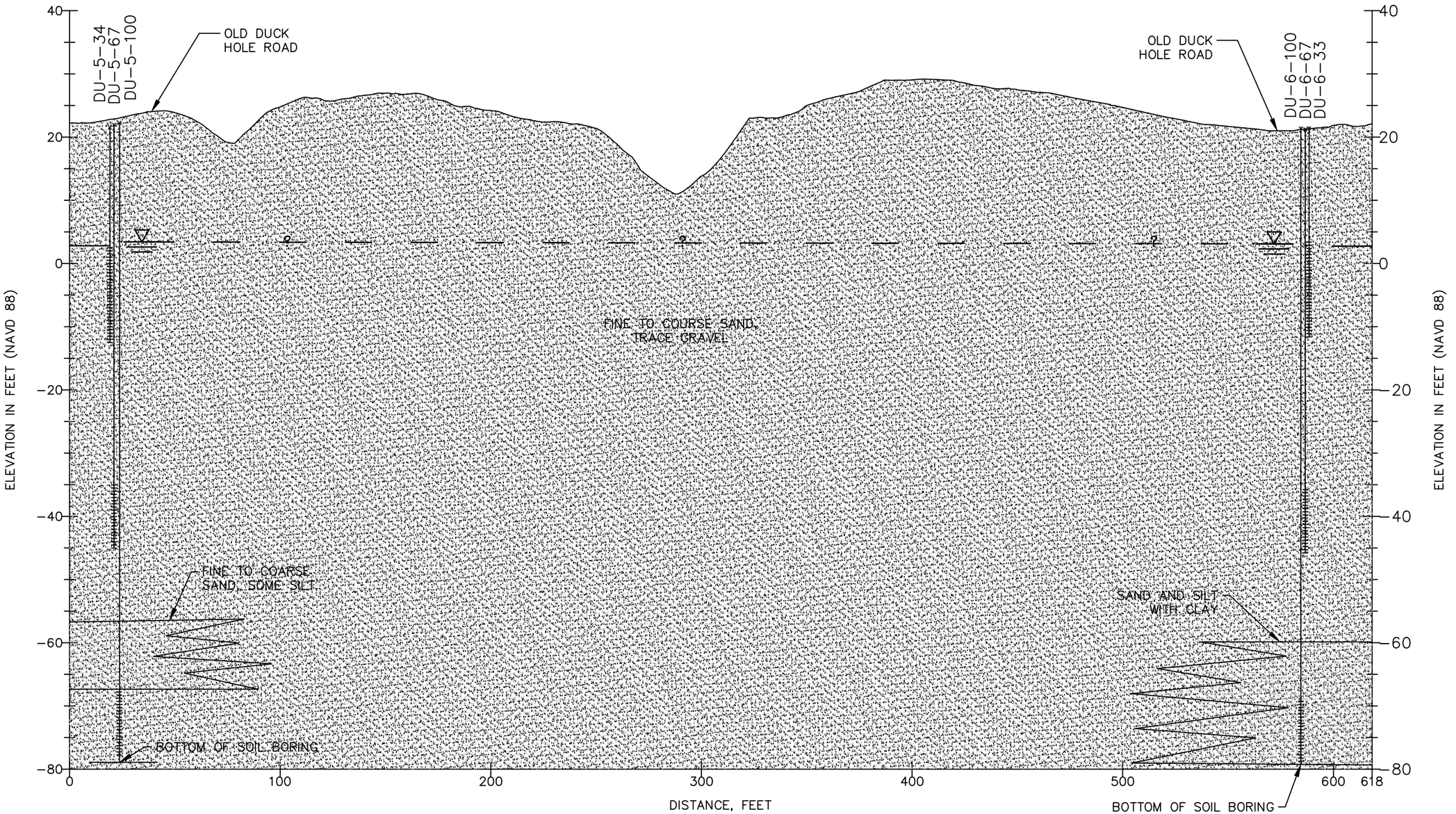
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Figure: 10

GEOLOGIC CROSS SECTION A-A'
DUCK HOLE PRB
TOWN OF ORLEANS, MA
Project No.: 60476644 Date: 2022-11-16

B (SOUTHWEST)

B' (NORTHEAST)



LEGEND

SAND

SILTY SAND

SILT AND CLAY

SAND AND GRAVEL

SILT

GROUNDWATER SURFACE

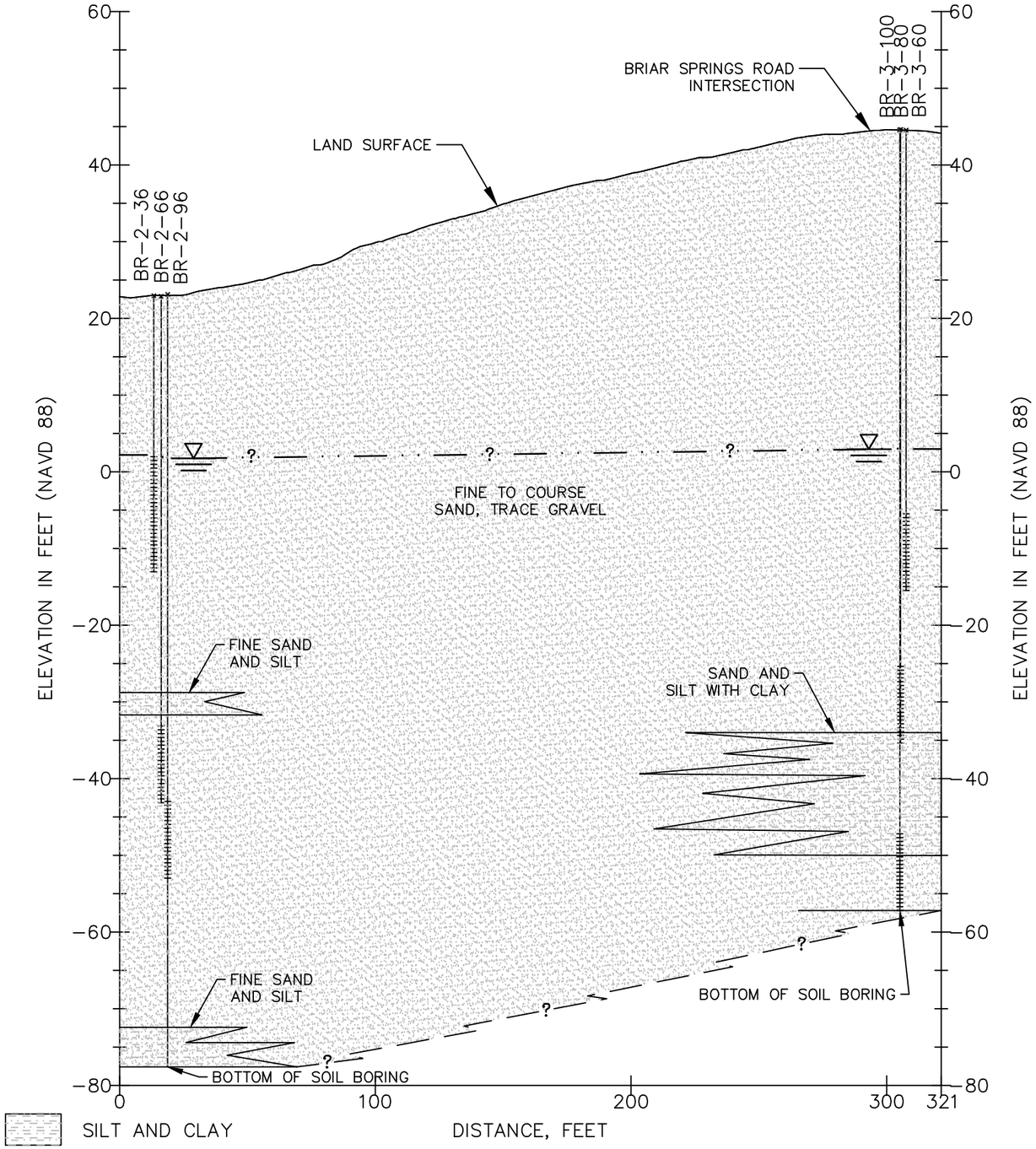
WATER TABLE

AECOM

Figure: 11

GEOLOGIC CROSS SECTION B-B'
DUCK HOLE PRB
TOWN OF ORLEANS, MA
Project No.: 60476644 Date: 2022-11-16

C (SOUTHWEST) **C' (NORTHEAST)**



LEGEND

SAND
SILTY SAND
SILT AND CLAY
SAND AND GRAVEL
SILT
GROUNDWATER SURFACE
WATER TABLE

GEOLOGIC CROSS SECTION C-C'
BRIAR SPRING PRB
TOWN OF ORLEANS, MA
Project No.: 60476644 Date: 2022-11-16

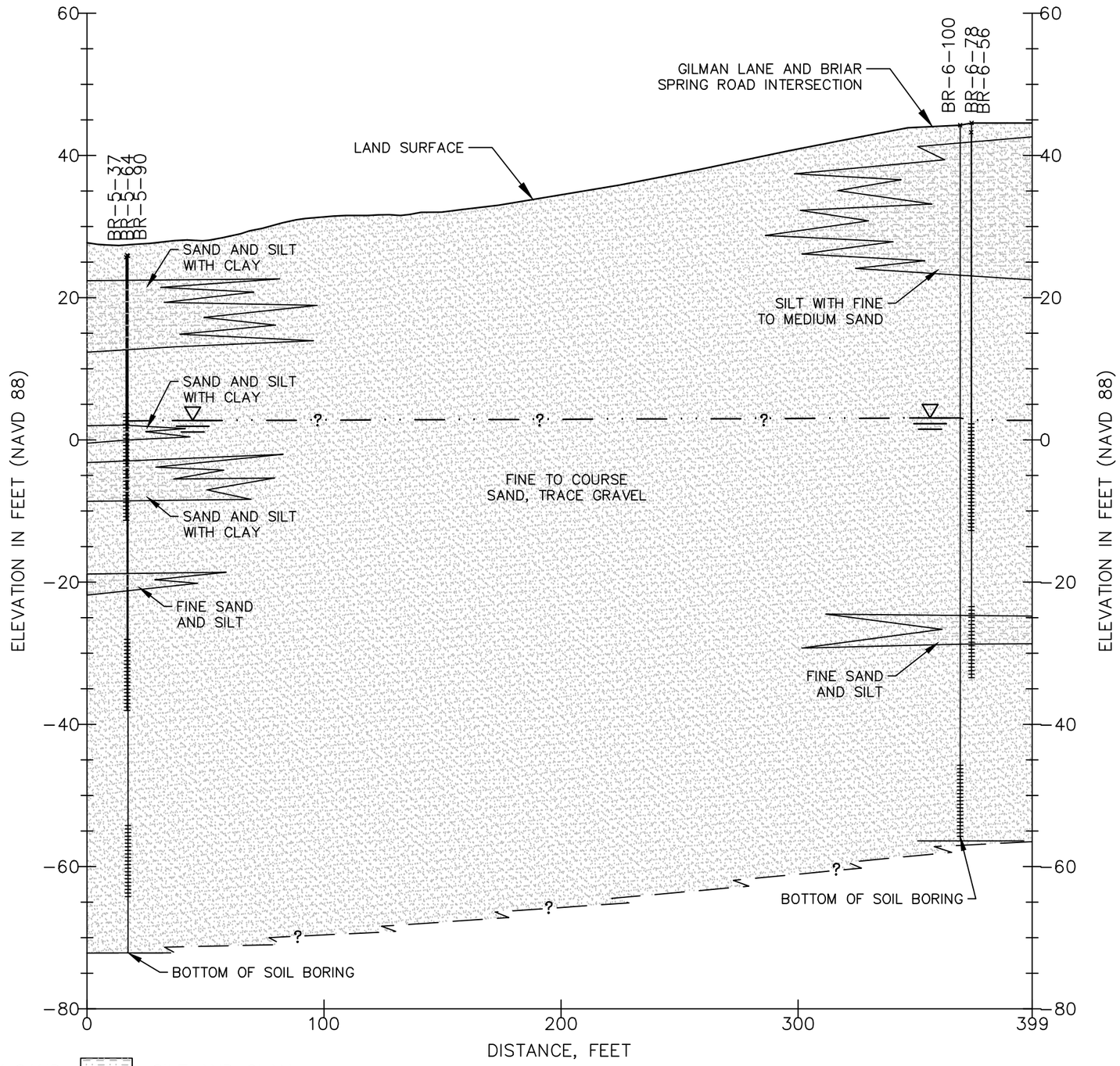
AECOM
Figure: 12

AECOM

Figure: 13

D (SOUTHEAST)

D' (NORTHWEST)



LEGEND

SAND

SILTY SAND

SILT AND CLAY

SAND AND GRAVEL

SILT

GROUNDWATER SURFACE

WATER TABLE

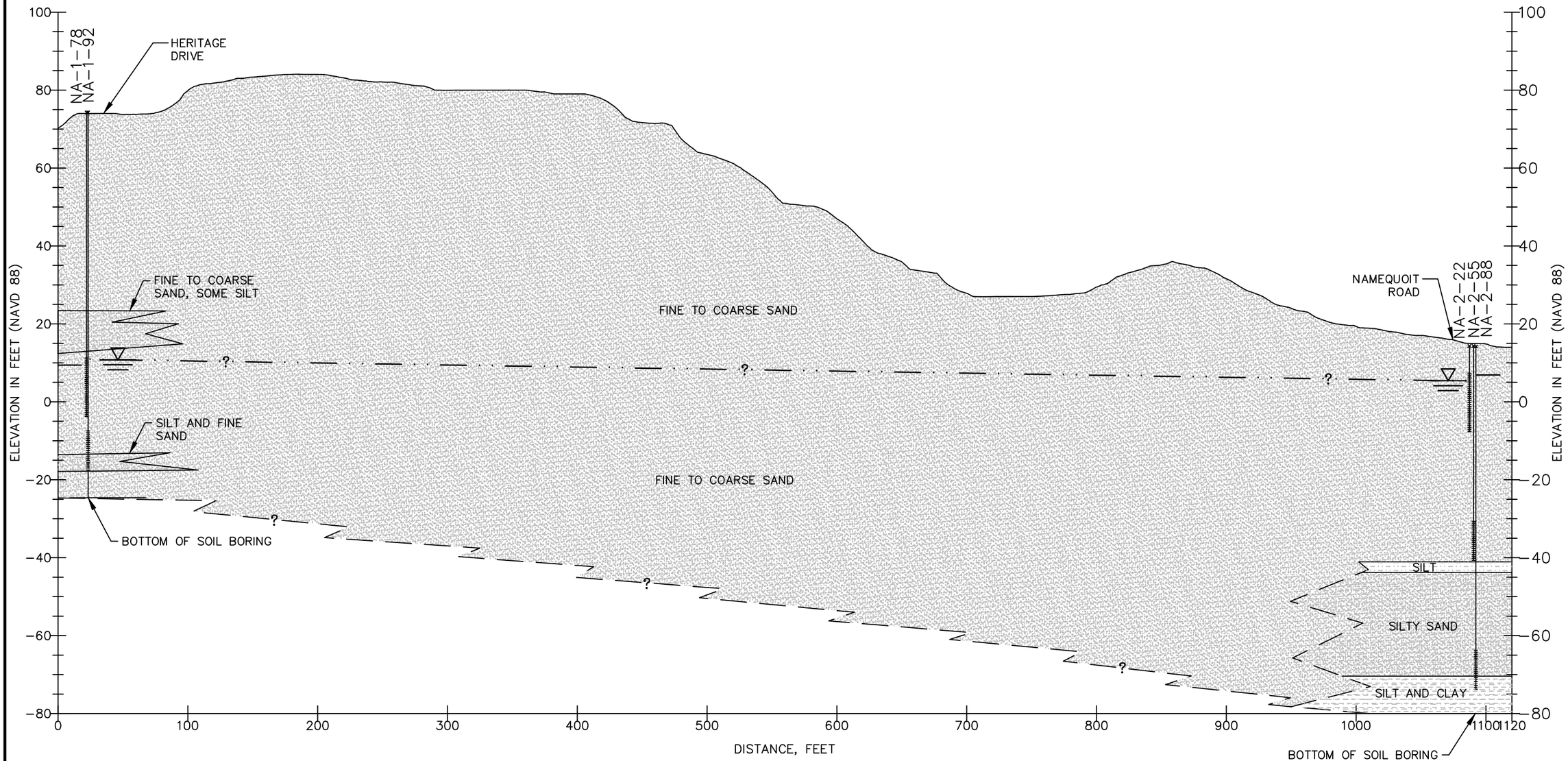
GEOLOGIC CROSS SECTION D-D'
BRIAR SPRING PRB
TOWN OF ORLEANS, MA
Project No.: 60476644 Date: 2022-11-16

AECOM

Figure: 14

E (SOUTHWEST)

E' (NORTHEAST)

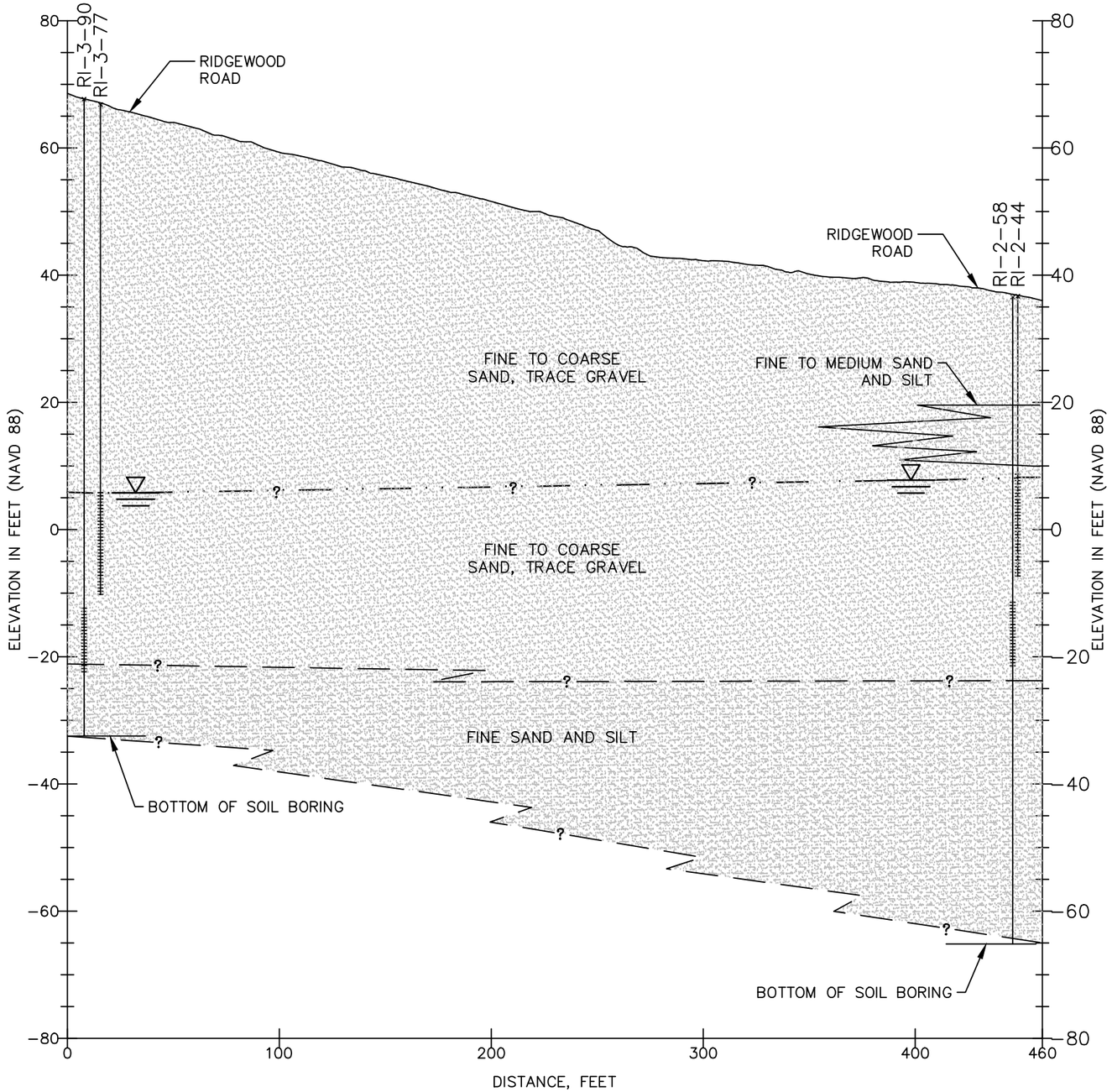


LEGEND

SAND | SILTY SAND | SILT AND CLAY | SAND AND GRAVEL | SILT | GROUNDWATER SURFACE | WATER TABLE

GEOLOGIC CROSS SECTION E-E'
NAMEQUOIT/RIDGE PRB
TOWN OF ORLEANS, MA
Project No.: 60476644 Date: 2022-11-16

F (NORTHWEST) **F (SOUTHEAST)**



LEGEND

SAND
SILTY SAND
SILT AND CLAY
SAND AND GRAVEL
SILT
GROUNDWATER SURFACE
WATER TABLE

AECOM

Figure: 15

GEOLOGIC CROSS SECTION F-F'
NAMEQUOIT/RIDGE PRB
TOWN OF ORLEANS, MA
Project No.: 60476644 Date: 2022-11-16

Appendix A: Implementation Plan for Full-Scale PRBs

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AECOM
9 Jonathan Bourne Drive
Pocasset, MA 02559
www.aecom.com

508.833.6950 tel
508.833.6951 fax

Memorandum

To	George Meservey, Director of Planning & Community Development
CC	Betsy Shreve, AICP, AECOM Project Director James Begley, LSP, MT Environmental AECOM PRB Team
Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 12.1.B – NT Demonstration Projects** **Task 12.1.B.2 - Technical Memorandum: Permeable Reactive Barriers (PRB)** **Full-Scale Watershed Planning - Final**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	January 7, 2021

1. Introduction

This Technical Memorandum has been prepared to identify potential full-scale Permeable Reactive Barrier (PRB) locations for implementation in accordance with the overall objectives of the Town of Orleans Amended Comprehensive Wastewater Management Plan (ACWMP). The ACWMP was developed in accordance with the Cape Cod 208 Water Quality Plan, which has been approved by both the United States Environmental Protection Agency (US EPA) and the Massachusetts Department of Environmental Protection (MassDEP).

The ACWMP is a "hybrid" plan that includes provisions for use of conventional wastewater treatment and non-traditional technologies, including PRBs, to remediate nitrate in groundwater. The PRB is a remediation technology that intercepts and removes nitrogen in groundwater at key locations in the watersheds before it discharges to sensitive embayments. Using a non-traditional technology allows for a reduction in sewer collection system coverage and wastewater treatment facility costs while still achieving nitrogen control objectives.

A PRB demonstration project is currently underway at the Eldredge Parkway site at the Nauset Regional Middle School in Orleans. The PRB was implemented in November 2016 and was designed for evaluating of PRB performance. Over the last four years, the project has shown that a PRB is effective in removing nitrate in groundwater. As part of the ACWMP, the Town is planning to install additional PRBs to reduce the nitrate load from nitrate impacted watersheds and estuaries in a cost-effective manner.

Three major watersheds have been identified for PRB groundwater remediation. These include the watersheds to Pleasant Bay, Nauset Estuary and Rock Harbor shown in Figure 1. A planning document Technical Memorandum "Permeable Reactive Barriers Implementation Plan for Full-Scale PRBs" (Implementation Plan) was prepared for the Town of Orleans dated August 6, 2018 and included details on the design and logistics of implementation of full-scale PRBs. The Implementation Plan for full-scale PRBs is in Appendix A and is also available on the Town of Orleans website https://www.town.orleans.ma.us/water-quality-and-wastewater-planning/pages/permeable-reactive-barriers-prb.

2. Orleans Nitrogen Load Reduction Objectives

The watersheds recharging Pleasant Bay, Nauset Estuary and Rock Harbor in Orleans include numerous sub-watersheds that discharge to creeks, rivers and salt ponds as shown in Figure 1. Total Maximum Daily Loads (TMDLs) define the maximum nitrogen load that the water body can receive from all sources, including watersheds, while still meeting necessary water quality criteria. To develop embayment specific TMDLs, the Massachusetts Estuaries Project (MEP) assessed nitrogen loading to the estuaries using an analytical method called the Linked Watershed-Embayment Management Modeling Approach. The model links watershed nitrogen inputs with surface water circulation and nitrogen characteristics to establish nitrogen loading threshold concentrations that must be achieved to restore and maintain water quality standards within the embayments. Exceeding thresholds has significant environmental consequences. For embayments that exceed the TMDL, corrective actions are needed to reduce nitrogen loading to achieve TMDLs in compliance with the federal Clean Water Act and state law.

Threshold nitrogen concentration and TMDLs were developed with results from analysis by MEP documented in technical reports prepared for Pleasant Bay, Rock Harbor and the Nauset Estuary (MEP 2006, MEP 2007, MEP 2012, respectively). The MassDEP and US EPA have approved nitrogen TMDLs for Pleasant Bay. Additional TMDLs are undergoing review by the regulatory agencies. TMDL thresholds and target goals for these estuaries are discussed in more detail below.

A. Pleasant Bay TMDLs

Pleasant Bay is connected to the Atlantic Ocean and is characterized by three main basins including Little Pleasant Bay, Pleasant Bay and Chatham Harbor. The bay has numerous sub-embayments. These sub-embayments are at particular risk of eutrophication from high nitrogen loads entering by direct groundwater discharge and by restricted tidal exchange. The main basins in or adjacent to Orleans include Pleasant Bay Main Basin and Little Pleasant Bay. Sub-embayments in Orleans include Meetinghouse Pond, the Upper and Lower River, Lonnie's Pond (also known as Kescayo Gansett Pond), Namequoit River and Aries Pond, Paw Wah Pond, Quanset Pond, and Pochet Inlet. The estimated nitrate loads to each of the watersheds and sub-watersheds are detailed in the MEP issued report "Massachusetts Estuaries Project Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Pleasant Bay System, Massachusetts" in May 2006.

In June 2017, the Select Boards of Brewster, Chatham, Harwich, and Orleans voted to sign a Resolution of the Towns sharing the Watershed of Pleasant Bay, endorsing the Pleasant Bay Composite Nitrogen Management Analysis as an accurate representation of each Town's share of the current nitrogen load and its responsibility to remove nitrogen in Pleasant Bay (Pleasant Bay Alliance, March 2017). The agreed Town of Orleans share of the Pleasant Bay Watershed nitrogen load is 6,980 kilograms per year (kg/yr) targeting sub-embayments as shown on Table 1.

The Towns also agreed to participate in a Watershed Permit Pilot Project with the Pleasant Bay Alliance, MassDEP, US EPA and the Cape Cod Commission (CCC) to pursue efficiencies and cost savings through coordinated implementation of nutrient management actions. The Pleasant Bay Watershed Permit was issued by MassDEP in August 2018 in accordance with M.G.L. c. 21, § 27(6) and Section 2A of Chapter 259 of the Acts of 2014.

At this time, the Town of Orleans has targeted 100 percent of its share of the nitrogen load to be removed by non-traditional technologies for Lonnie's Pond, Arey's Pond, Lower River, Namequoit River, Paw Wah Pond, Quanset Pond, Pochet, Pleasant Bay Main Basin and Little Pleasant Bay. Other sub-embayment removal goals have smaller targets for non-traditional technologies including 2 percent for Meetinghouse Pond, which will be mainly addressed with conventional wastewater collection and treatment system and 54 percent for the Upper River. Given the expected favorable economic benefits of utilizing non-traditional technologies, the current objective for full-scale PRB selection in this evaluation was to consider all feasible locations within the Pleasant Bay Watershed.

B. Nauset Harbor Embayment System TMDLs

The Nauset Harbor Embayment System in Orleans and Eastham is connected to the Atlantic Ocean and is comprised of open waters including Nauset Harbor, Town Cove, Nauset Marsh (located behind Nauset Barrier Beach) and three sub-embayments: Salt Pond, Wood Cove and Mill Pond. The Nauset Harbor Estuary watershed is shared by the Towns of Orleans, Eastham and Brewster. The most impacted areas with impaired habitat and therefore the focus of nitrogen load reduction in Orleans, include the upper reach at Town Cove and the semi-enclosed Mill Pond and Wood Cove sub-embayments. The Salt Pond sub-embayment in Eastham is also at risk of eutrophication. MEP issued the report "Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Nauset Harbor Embayment System, Towns of Orleans and Eastham, Massachusetts" in 2012 to support TMDLS for the estuary.

The Nauset Embayment System exceeds the MEP established TMDL requiring measures to lower the combined watershed nitrate load to the estuary (Howes et. al., 2012). The Town Cove nitrate TMDL is 21,432 kg/yr with a Target Threshold Watershed Load (comprised of natural background, fertilizer, runoff and septic system loads) of 4,368 kg/yr. According to the MEP report, the existing Watershed Load is 11,532 kg/yr. Therefore, a reduction of 7,164 kg/yr of nitrogen load is necessary to restore and maintain the Town Cove's water quality below the Target Threshold Load. Orleans has identified a PRB technology removal target or goal of 566 kg/yr for Town Cove. The objective for full-scale PRB selection in this evaluation was to consider all feasible locations within the Nauset Watershed.

C. Rock Harbor Embayment System TMDLs

The Rock Harbor Embayment System is in the Towns of Orleans and Eastham. Rock Harbor is a man-made harbor at the mouth of a tidal river and salt marsh and opens to Cape Cod Bay to the north. Significant habitat quality impairment and the presence of algal mats have been observed in the lower reach harbor area, while the upper reach marsh area has a higher quality habitat. MEP issued the report "Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Rock Harbor Embayment System, Towns of Orleans, Massachusetts" in December 2008 to support TMDLs for the estuary. The Rock Harbor System total TMDL 1,827 kg/yr with at Target Threshold Watershed Load of 1,358. The Present Watershed Load, comprised of natural background, fertilizer, runoff, WWTF and septic system loads, is 3,309 kg/yr, leaving 1,951 kg/yr to be removed. The Orleans' PRB technology removal target for nitrate is 634 kg/yr. The objective in this evaluation was to consider all possible locations within the Rock Harbor Watershed.

3. Site Selection Process

The PRB site selection process documented in this technical memorandum has identified 14 potential PRB locations within the sub-watersheds to Pleasant Bay, 3 PRB locations in the Nauset watershed and 1 location within the Rock Harbor watershed. PRBs were identified using local roadway names. Location and physical characteristics of the potential PRBs are included in Table 2 and shown on Figure 2.

A variety of information sources were used to support the PRB selection process. Land use was reviewed in the Orleans Geographic Information System https://www.town.orleans.ma.us/planning-department/pages/gis-mapping. Hydrogeologic information including groundwater flow and watershed delineations were gathered from MEP reports and from the regional USGS Monomoy Lens groundwater model (Walter and Whealan, 2005). Additional groundwater data were obtained from a 1990s CCC investigation of soils, water level and water quality data across the Town of Orleans. The CCC gathered soil boring and water level data from numerous previous investigations and installed additional soil borings and monitoring wells to evaluate soil and groundwater elevations throughout Orleans. These data were summarized in a report titled "Orleans Water Table Mapping Project, Orleans Massachusetts", dated May 1995.

Full scale PRB location screening considered overall nitrogen remediation objectives, environmental conditions, land use, downgradient water use, topography, wastewater nitrogen load upgradient within the capture zone of the PRB and practical limitations to cost effective implementation of the technology.

4. PRB Characteristics and Initial Siting Criteria

Initial PRB siting criteria were used to assess potential full-scale PRB locations in each of the three major watersheds. Criteria included:

- Locating PRBs along roadways that are cross-gradient to the regional groundwater flow direction and within a watershed requiring long term groundwater remediation;
- The depth to groundwater, generally less than 40 feet (depth affects costs and may affect feasibility);
- The accessibility of the PRB for installation, upgradient and downgradient monitoring well installation, and long-term monitoring; and
- The location where groundwater discharges to the most sensitive upper reaches of the estuary where possible.

A PRB screening matrix was developed to identify relevant characteristics and record results of assessments of effectiveness discussed below. Candidate locations were mapped, depth to groundwater was estimated based on topography and groundwater elevation contours and the vertical extent of the PRB was defined. Screening included evaluation of roadway orientation upgradient of target embayments, considering sub-watersheds to determine PRB location and PRB total length. The road layout and land use assessment utilizing the Orleans Geographic Information System (GIS) database was followed up with field surveys.

5. Detailed Analysis of PRB Effectiveness

Potential PRB locations identified in the initial screening were assessed for effectiveness of nitrogen mass removal by evaluating:

- The dimensions of the proposed PRB;
- Groundwater flow direction;
- The density of wastewater nitrogen sources upgradient of and within the capture zone of the PRB; and
- The ability in aggregate to achieve PRB nitrate mass remediation goals given the current assumptions.

The density of septic system wastewater nitrogen sources was assessed by estimating the number of parcels within the capture zone or area of groundwater intercepted by the PRB and then calculating the nitrogen load generated in that area with specified assumptions. A feasible PRB installation depth of approximately 70 to 80 feet below ground surface was assumed. This depth limitation and the depth to groundwater affects the size of the upgradient capture zone of a PRB. The upgradient area of groundwater that will flow through the PRB is limited because groundwater generally flows deeper into the aquifer as it moves towards the receiving water. Once it reaches the receiving water body groundwater moves up to discharge. At a certain distance upgradient, groundwater originating further upgradient will flow under the PRB and groundwater from that area cannot be treated by the PRB.

AECOM developed a groundwater flow model for the Town of Orleans based on the USGS, Sagamore and Monomoy flow lens Model (Walter and Whealan 2005). This model has been previously used to evaluate groundwater mounding and alterations to groundwater flow paths resulting from the proposed WWTF Groundwater Discharge at 32 Lots Hollow Road and 43 Lots Hollow Road in Orleans (AECOM, 2018). The model is also suitable for evaluating the area contributing groundwater to the proposed PRBs. The capture zone area was estimated by using the model to backtrack particles, simulating a drop of water's flow path, upgradient of each PRB. This was accomplished by using MODPATH (Pollock, 1994) in conjunction with the MODFLOW (McDonald and Harbaugh, 1988) software.

The wastewater load within the defined capture zone was then estimated by counting parcels within the capture zone and assigning an annual nitrogen load for the PRB. This estimate considers wastewater related nitrogen only and does not account for fertilizer applied to the land and atmospheric deposition of nitrogen within the capture zone. The wastewater load estimate assumed one house per parcel. The parcel nitrate load assigned was based on a reference wastewater nitrogen concentration of 26.25 mg/L used in MEP studies and a town-wide average water use of 150 gallons per day per parcel based on Orleans water records for 2014 and 2015. The estimated annual nitrogen load generated per parcel was 5.44 kg/yr.

Nitrogen from fertilizer, atmospheric deposition, and the presence of multi-unit condominiums on one parcel would increase the estimated nitrogen load in the capture zone. MassDEP has indicated a preference for use of actual nitrogen flux data and PRB nitrogen removal performance for determining the nitrogen load removal credit assigned to PRBs. However, the MEP based estimate of 5.44 kg/yr has been used as a surrogate in this evaluation. Ultimately PRB performance will be measured by actual groundwater nitrogen load and PRB reduction as determined through groundwater monitoring.

Prior to assigning a nitrate load to each parcel, the parcels were reviewed for land use type and mapped conservation land and parcels without obvious development were not counted. The parcel count is included in Table 3. PRB lines, particle backtracks, and highlighted parcels show the capture zones and counted parcels on Figure 2. For the purposes of site selection screening, the assumed nitrogen load removal by PRBs is 80 percent of the wastewater load generated within the capture zone. Current monitoring of the Eldredge Parkway Demonstration PRB indicates a greater than 80 percent nitrogen removal efficiency. However, it is anticipated that an 80 percent efficiency will be selected as the target for PRB management over time, triggering replenishment of PRB carbon source once average efficiency drops below 80 percent.

The estimated annual nitrogen load in the capture zone of each PRB was normalized to PRB length to assess load reduction on a kilogram per linear foot per year (Kg/LF/yr) basis for comparison with other potential PRBs. The estimated PRB efficiency considering all locations ranged from 0.09 to 0.40 Kg/LF/yr. PRBs in each major watershed were ranked for efficiency and given a rank as shown in Table 3.

The calculated efficiency was supplemented with a qualitative evaluation of PRB location relative to the most impacted sub-embayments based on MEP modeled total nitrogen concentrations and embayment specific non-traditional technology goals to guide potential funding and implementation planning.

6. Implementation Cost

AECOM has estimated the implementation cost for each PRB installation based on $1,230.00 per linear foot of PRB line. This cost includes:

- Town administration;
- Engineering design;
- Monitoring well installation and baseline sampling;
- Injection contractor and sub-state costs; and
- Engineering oversight of implementation.

PRB implementation costs range from $492,000 for a 400-foot PRB to $8,979,000 for a 7,300-foot PRB as shown in Table 4. Additional future costs will include long term monitoring, replacement costs for any damaged monitoring wells and subsequent substrate injection events. These costs were developed for the Wastewater Infrastructure Long Term Financial Plan that will address a phased implementation schedule for selected PRBs over a 10-year period.

7. Life Cycle Cost Analysis

A Life Cycle Cost Analysis (LCCA) was performed to compare PRBs and Traditional Systems. The purpose of this LCCA was to estimate the overall costs of PRBs and Traditional Systems and to utilize the information to assist the Town in selecting the alternative which will provide the lowest overall cost (implementation plus operation and maintenance) based on a cost per kg nitrate removed.

For both the PRBs and Traditional Systems, numerous costs associated with implementation (e.g. planning, design, bidding, construction, etc.) plus operation and maintenance of each the alternative was estimated. The following summarizes the unit costs utilized for the LCCA.

PRBs

Description	Unit Cost
Implementation Cost [1] ($/LF)	$1,230
Replacement Cost [2] ($/LF Annual basis)	$63
Monitoring Cost [3] ($/LF)	$17

Notes:

1. Unit costs developed based on the Eldredge Park Way PRB Demonstration Project.
2. Replacement costs will occur every 15 years for PRB reinjection.
3. Monitoring costs represent an average on $/LF basis. This may vary by location due to reporting efforts and costs.

Traditional Systems

Description	Unit Cost
Collection System and Pumping Stations	
Gravity Sewer (lf)	$425
Low-Pressure Sewer (lf)	$200
Pumping Station (each)	$1,500,000
Force Main (lf)	$200
Highway Crossing (l.s.)	$500,000
O&M Cost ($/gal)	$1.75
WWTF and Aquifer Recharge	
WWTF ($/gal)	$100
Force Main (lf)	$200
Effluent Disposal ($/gal)	$10
O&M Cost ($/gal)	$3.25

Notes:

1. Based on the Average of Bids Received on May 6, 2020 for Contract 2019-02 - Downtown Area Collection System and Pumping Stations
2. O&M Cost Based on Estimated O&M Cost for Contract 2019-02 - Downtown Area Collection System and Pumping Stations
3. Based on the Average of Bids Received on May 13, 2020 for Contract 2019-01 - Downtown Area WWTF and Effluent Disposal
4. O&M Cost Based on Estimated O&M Cost for Contract 2019-01 - Downtown Area WWTF and Effluent Disposal

The LCCA utilized the following assumptions:

Factors	N Removal
Term at 30, 60 and 100 Years	Utilized 26.25 mg/l per MEP Studies
Interest Rate at 1.5%	PRBs - 80% Removal from Watershed
Inflation at 3.0%	Traditional System - 100% Removal from Watershed

The PRB LCCA costs (on a cost per kg nitrate removed basis) were than compared to the Traditional System LCCA costs (on a cost per kg nitrate removed basis). Conclusions are as follows:

1. When compared to Traditional Systems approximately:
    a. 80 percent of the proposed PRBs are more cost effective (on a cost per kg nitrate removed basis) over a 30-year life-cycle cost analysis; and
    b. 27 percent of the proposed PRBs are more cost effective (on a cost per kg nitrate removed basis) over a 100-year life-cycle cost analysis.
2. The proposed PRBs at Granny's, Richwood, Blossom and Norseman are more cost effective (on a cost per kg nitrate removed basis) compared to the Traditional Systems based on the 30-year, 60-year and 100-year life-cycle costs.
3. The proposed PRBs at Winslow, Gosnold and Rock Harbor are not as cost effective (on a cost per kg nitrate removed basis) as compared to the Traditional Systems based on the 30-year, 60-year and 100-year life-cycle costs.

Refer to the following summary; Table 4 for the 30-year, 60-year and 100-year life-cycle cost analysis for PRBs; and Table 5 for the 30-year, 60-year and 100-year life-cycle cost analysis for Traditional Systems.

Comparison of PRBs and Tranditional Systems on a Cost per kg Nitrate Removed Basis						
PRB Description	LCCA at 30 Years		LCCA at 60 Years		LCCA at 100 Years	
	PRBs	Traditional System	PRBs	Traditional System	PRBs	Traditional System
Pleasant Bay Estuary						
Monument	X			X		X
Keziah's	X			X		X
Mayflower	X		X			X
Namequoit, Ridge & Lockwood	X		X			X
Quonset 1, 2, & 3	X		X			X
Granny's	X		X		X	
Winslow		X		X		X
Richwood	X		X		X	
Duck Hole	X			X		X
Gosnold		X		X		X
Briar Spring	X			X		X
Blossom	X		X		X	
Nauset Estuary						
Tonset Road and Main Street	X			X		X
Norseman	X		X		X	
Rock Harbor Estuary						
Rock Harbor		X		X		X
Totals	12	3	7	8	4	11

8. Consideration of Current Groundwater Use for Water Supply

Groundwater is currently used for water supply throughout the Town of Orleans. The Town operates municipal wells and has a water main distribution system servicing much of the Town. Private potable water supply wells are scattered throughout the Town with concentrations of these wells in certain areas. Parcels with private wells are shown on Figure 2. PRBs were only considered at locations downgradient of zones of contribution to municipal wells. AECOM assessed the distribution of private wells through town records and identified several potential private wells and parcels with potential private wells downgradient of PRBs. Parcels with private wells near potential PRBs appear to also be located adjacent to town municipal water mains and will need to be connected to town water to avoid any potential secondary water quality effects to potable water and to facilitate permitting PRB injection through the Massachusetts Underground Injection Control Program.

9. Conclusions

The performance of PRBs was considered against specific nitrogen reduction goals for non-traditional technologies. In certain watersheds, such as the watersheds to Town Cove and Meetinghouse Pond, traditional wastewater treatment will provide most of the nitrogen load reduction necessary to achieve TMDLs. Enhanced aquaculture will be also be pursued as an additional non-traditional technology but will not be assigned a specific share of the non-traditional remediation goal for watershed permitting in current planning.

The PRB siting criteria that specifies locating PRBs along roadways that are cross-gradient to the regional groundwater flow direction is important for access and feasible installation. However, this criterion also significantly limits the locations that can be selected. This limitation is considered the single most restrictive criterium for placement of PRBs, affecting PRB options and achievement of nitrogen remediation goals. Areas with significant concentrations of private wells were also avoided in locating PRBs due to concern for potential impacts to drinking water quality. A modified approach to PRB installation may be necessary to select additional locations or other alternatives may be necessary to achieve remediation goals. The ability of PRBs to achieve specific watershed goals are discussed in more detail below.

A. Pleasant Bay PRBs

A total of fourteen PRBs were identified in the Pleasant Bay Watershed. PRBs were placed in targeted sub-watersheds to the extent possible. Nitrogen removal requirements for sub-embayments are presented in Table 1. Nitrogen remediation requirements for Quanset Pond were included with Pleasant Bay/Little Pleasant Bay in this analysis due to difficulties in addressing Quanset Pond directly, giving a total of nine remediation goals used for comparison to estimate nitrogen load reductions. Measures of PRB effectiveness in relation to remediation goals are presented in Table 3 including:

- Estimated sewer load reduced (kg/yr) at 80% PRB efficiency;
- Percentage of embayment non-traditional technology goal achieved; and
- Estimated PRB efficiency (kg/LF/yr).

The nine targeted sub-watersheds cannot be fully remediated with PRBs to exceed the required non-traditional technology targets with the given assumptions. The overall projected PRB nitrogen reduction for Pleasant Bay based on the given assumptions was 2,115 kg/yr which is less than half the total Pleasant Bay non-traditional technology remediation goal of 4,966 kg/yr. However, the proposed PRBs could remove a significant percentage, ranging from 29 percent to 70 percent of the required removal load to impacted sub-watersheds.

The most efficient PRB in the Pleasant Bay watershed on a kilograms-of-nitrogen removed per linear foot per year basis was the Ridge (Ridgewood Road) PRB with a nitrogen removal efficiency of 0.27 Kg/LF/yr. In combination, the Ridge PRB and the Namequoit (Namequoit Road) PRB achieved an estimated 70 percent reduction in targeted nitrogen load to the Namequoit River. The Namequoit River is also an upper reach priority embayment that is significantly impacted by nitrogen load. Nitrogen load reduction in upper reaches of the estuary is a priority because upper reaches are the most impacted and nitrogen reduction in upper reaches will also benefit all lower areas in the estuary closer to the inlet to the bay.

Four PRB locations were identified in the Pochet Neck Stream and Pochet watersheds which is also a priority upper reach of the estuary with significant impact from nitrogen load. In combination these PRBs would remove 48 percent of the 1,564 kilograms of nitrogen load targeted for Pochet.

PRB locations could not be identified for Arey's Pond mainly due to roadway orientation and developed parcel locations. Meetinghouse Pond watershed will be remediated with conventional wastewater treatment and no PRB were located in the Meetinghouse Pond sub-watershed.

B. Nauset Estuary PRBs

Three potential PRBs were identified for the Nauset Estuary with a total projected nitrogen remediation of 866 kg/yr, which significantly exceeds the non-traditional technology goal of 566 kg/yr for Town Cove. The Tonset PRB was the largest identified and could be considered to help achieve the 7,164 kg/yr of nitrogen load reduction necessary to restore and maintain the Town Cove's water quality on an interim basis, treating existing load already in the groundwater while traditional wastewater systems are brought online. The relatively small 750-foot-long Main Street PRB was projected to be very efficient with a nitrogen removal of 0.4 Kg/LF/yr while the much longer Tonset PRB had a significantly lower nitrogen removal efficiency of 0.06 Kg/LF/yr.

C. Rock Harbor PRBs

One PRB location was identified for Rock Harbor along Rock Harbor Road that is estimated to remove 305 kg/yr of nitrogen which is less than half the Rock Harbor non-traditional remediation goal of 634 kg/yr. The Rock Harbor PRB had a relatively low nitrogen removal efficiency of 0.08 kg/LF/yr.

The results of the effort to identify potential full-scale PRB locations indicated there are many viable options for PRBs. Preliminary analysis indicates some locations are clearly more efficient and cost effective than others. PRBs identified in this process do not fully achieve nitrogen remediation goals for non-traditional technologies and additional alternatives may be required. The identified PRBs do however provide an important starting point for implementation of non-traditional technologies and are expected to provide for significant nitrogen removal. Actual groundwater data from field investigations will be necessary to confirm expected PRB performance in relation to remediation goals and may indicate higher effectiveness by accounting for additional nitrogen sources and/or higher source strength than considered in the screening assumptions. Groundwater data and a calculated mass flux of nitrogen is the MassDEP's preferred method for assessing PRB performance. The field data collected from monitoring wells will be used to assess the actual mass of nitrogen intercepted by the PRB on an annual basis.

Each of the potential PRB locations were evaluated based on the following considerations:

- Estimated PRB Efficiency (kg/LF/yr)
- Ability to meet PRB Non-traditional technology goal (kg/yr)
- Life Cycle Cost Analysis (PRBs vs Traditional System)
- Secondary Water Impacts (Public and Private Water Supplies: Existing and Future)
- Location of PRBs vs. Wastewater Service Areas
- PRB location with regards to embayment
- Watershed Compliance (N Reduction)
- Environmental Response (Short Term vs. Long Term)
- Implementation Costs (Capital Improvement Plan)

Critical factors include the estimated PRB efficiency (Kg/LF/yr), location, and ability to contribute to remedial goals (percent nitrogen reduction). Even PRBs with relatively low efficiency can be beneficial if sufficient length can be installed to achieve significant nitrogen reduction (% N reduction). In some cases, short length PRBs with high efficiency but low % N reduction can be worthwhile and are cost effective. In addition, PRB location with respect to the upper reach or head of the estuary matters. The upper reaches are the most impacted by eutrophication from nitrogen loading, with documented overload of nutrients. Reducing nitrogen loading in the upper estuary improves water quality throughout the bay. The following table presents the results of the evaluation as well as identifies as to whether the location is feasible for PRB implementation.

Embayment	PRB Name	Remarks	Feasible PRB Location (Y / N)
Pleasant Bay Estuary (Orleans)			
Meetinghouse Pond	None	N/A Conventional treatment	N/A
Lonnies Pond / Kescayo Gansett River	Monument	• High priority upper reach • Higher efficiency • Significant % N reduction	Y
Aery's Pond	None	Fails to meet siting criteria	N
Upper River	Keziahs	• High priority upper reach • Moderate efficiency • Significant % N reduction	Y
Lower River	Mayflower	• High priority upper reach • Moderate efficiency • Low % N reduction	Y
Namequoit River	Namequoit	• High priority upper reach • Higher efficiency • Highest % N reduction	Y
	Ridge	• High priority upper reach • Highest efficiency • Highest % N reduction	Y
Pah Wah Pond	Lockwood	• High priority upper reach • Moderate efficiency • Lower % N reduction	Y
Quanset and Pleasant Bay Main Basin	Quonset 1,2,3	• High priority upper reach • Moderate efficiency • Significant % N reduction	Y
	Grannys	• Lower priority location • Higher efficiency • Moderate % N reduction	Y
	Winslow	• Lower priority location • Low efficiency • Low % N reduction	N

Embayment	PRB Name	Remarks	Feasible PRB Location (Y / N)
Pochet	Richwood	• Lower priority location • Higher efficiency • Significant % N reduction	Y
	Duck Hole	• High priority upper reach • Lower efficiency • Significant % N reduction	Y
	Gosnold	• High priority upper reach • Low efficiency • Moderate % N reduction	Y
	Briar Spring	• High priority upper reach • Moderate efficiency • Significant % N reduction	Y
	Blossom	• High priority upper reach • Higher efficiency • Low % N reduction	Y
Nauset Estuary (Orleans)			
Town Cove	Tonset	• High priority upper reach • Low efficiency • High % reduction	Y
	Main	• High priority upper reach • High efficiency • High % reduction	Y
Mill Pond	Norseman	• Lower priority location • Higher efficiency • Significant % reduction	Y
Rock Harbor Estuary (Orleans)			
Rock Harbor	Rock Harbor	• High priority upper reach • Lower efficiency • Significant % reduction	Y

Not all feasible PRBs are recommended for implementation and some of the feasible PRBs are less beneficial than others and should be installed after the more advantageous locations. The Rock Harbor PRB and the Nauset Watershed Tonset PRB are in areas adjacent to planned conventional wastewater treatment service areas and would be better served by extending the conventional system. The Rock Harbor and Tonset PRBs are therefore not recommended for additional investigation. The potential Winslow PRB in the Pleasant Bay Watershed does not rank high enough to be considered for implementation due to projected low efficiency and low nitrogen removal, in addition to being in an area that does not affect the upper reaches or a confined sub-embayment of Pleasant Bay.

Implementation of the remaining feasible PRBs in the watersheds to Nauset Estuary and Pleasant Bay should move forward. In Nauset Estuary the recommended PRBs include the Main Street PRB adjacent to Town Cove, a relatively short cost effective PRB at a location that could provide a significant short-term benefit prior to the water quality improvements resulting from the Downtown conventional system. If implemented this PRB could address nitrogen already released to groundwater and migrating to Town Cove over the next 20 years. The Norseman PRB is also a relatively short PRB that is cost effective and would improve water quality in the Mill Pond sub-embayment. These locations should be investigated as described in the Next Steps presented below.

The remaining 13 PRBs in the Pleasant Bay Watershed should also move forward in the process and be investigated to confirm hydrogeologic conditions and water quality. A priority for implementation should be established based on the additional information and consideration of efficiency and nitrogen reduction potential.

10. Next Steps

Additional effort is necessary to confirm potential PRB locations and plan the appropriate sequencing of PRB implementation. Additional criteria for final selection of PRB locations will include site specific investigations and evaluations as follows:

A. Continue PRB Watershed Planning in order to reduce nitrogen based on the results of the Eldredge Park PRB Demonstration Test and previous Watershed Planning Activities. Conduct (a) field investigations; (b) subsurface investigations; and (c) sampling, analysis and evaluation on the following:

- Two potential PRB locations in the Nauset Estuary
  - ✓ Main Street
  - ✓ Norseman
- Thirteen potential PRB locations in the Pleasant Bay Estuary
  - ✓ Blossom
  - ✓ Briar Spring
  - ✓ Duck Hole
  - ✓ Gosnold
  - ✓ Grannys
  - ✓ Keziahs
  - ✓ Lockwood
  - ✓ Mayflower
  - ✓ Monument
  - ✓ Namequoit
  - ✓ Quonset 1,2,3
  - ✓ Richwood
  - ✓ Ridge

B. Field Investigations

- Perform field investigations to confirm suitability of the proposed PRB locations along roadways; types of utilities present; roadway ownership; accessibility for upgradient and downgradient monitoring well installation and long-term monitoring; and potential environmental impacts.
- Based on Board of Health information, verify the location and status of any private wells located in the vicinity of the proposed PRBs.
- Field investigations to occur on up to ten PRB locations.

C. Subsurface Investigations

- Perform subsurface investigations to obtain subsurface geologic condition and to confirm groundwater flow directions and water quality.
- Subsurface investigations to occur as follows:
  - ✓ Part 1 – Conduct drilling operations with soil sampling, groundwater profiling, and groundwater monitoring well installation and sampling at up to three locations at each potential PRB site. Based on the information obtain, evaluate the feasibility of each location as a potential PRB location and conduct additional subsurface investigations at sites which are deemed feasible.
  - ✓ Part 2 – Conduct drilling operations with soil sampling, groundwater profiling, and groundwater monitoring well installation and sampling at up to five additional locations at each potential PRB site identified as feasible.

D. Sampling, Analysis and Evaluation

- Obtain hydrogeologic information and results of groundwater analyses and conduct an evaluation to develop a baseline nitrogen concentration profile, geologic and geochemistry data to support a cost-effective implementation.
- Sampling and evaluation to occur on up to eight monitoring well locations at each PRB.

E. Regulatory and Local Coordination

- Coordinate with the MassDEP, the Town of Orleans and the Pleasant Bay Alliance to discuss planning activities, the results of the investigations and the evaluation of the proposed PRB site. Setup and participate in up to two meetings.
- Update the Town's webpage to include documents and presentations prepared as part of this phase of the project.

F. Update the Full-Scale Watershed Planning Report – Update the Full-Scale Watershed Planning Report to incorporate the planning activities, the results of the investigations and the evaluation of the proposed PRB sites.

G. Meetings

- Prepare for and conduct two public meetings with the Select Board, Board of Water and Sewer Commissioners, Planning Department and the public at large to obtain stakeholder input;
- Prepare for and conduct four coordination meetings Board of Water and Sewer Commissioners, Planning Department and Department of Public Works and Natural Resources the public at large to obtain stakeholder input.

This Technical Memorandum provides information for review by public stakeholders to facilitate ongoing public involvement in the process. Prior to final selection, location-specific assessment are necessary to confirm existing conditions and the nature of hydrogeological conditions and groundwater chemistry to estimate nitrogen flux at PRB locations.

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Tables

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Table 1
Orleans PRB Selection Matrix

Pleasant Bay Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	Length (ft)	Roads	Saturated Depth (ft)	Depth Range to GW (ft)	Estimated Parcels	Estimated Sewer Load reduced (kg/yr) at 80% PRB Efficiency	Embayment Non-Traditional Technology Goal (kg/yr)	Estimated kg/LF/yr	Pleasant Bay Watershed PRB kg/yr Efficincy Rank	PRB Installation Cost Estimate	30-year LCCA for PRB (Present Worth)	Evaluation Notes
Meeting House Pond	None						**0**	**0**	**40**					
Lonnies Pond/Kescayo Gansett River							**41**	**178**	**284**					
Lonnies Pond/Kescayo Gansett River	Monument	25, 26 Lonnies Pond/Kescayo Gansett River	1,675	Monument	30	25 to 50	41	178		0.11	**8**	$2,060,250	$4,889,900	Upper Reach Priority embayment
Aerys Pond	None						**0**	**0**	**113**					
Upper River							**26**	**113**	**202**					
Upper River	Keziahs	41 Upper River	1,250	Keziahs	30	15 to 40	26	113		0.09	**9**	$1,537,500	$3,775,700	Upper Reach Priority embayment
Lower River							**35**	**152**	**517**					
Lower River	Mayflower	28 Lower River	1,700	Pershing, Kenneth	30	10 to 30	35	152		0.09	**11**	$2,091,000	$4,969,200	
Namequoit River							**56**	**244**	**348**					
Namequoit River	Namequoit	30 Namequoit River	1,000	Namequoit Road	30	10 to 40	27	117		0.12	**6**	$1,230,000	$7,577,200	Upper Reach Priority embayment
Namequoit River	Ridge	30 Namequoit River	460	Ridgewood Rd	30	10 to 30	29	126		0.27	**1**	$565,800	d with Namequoit PRB	Upper Reach Priority embayment
Pah Wah Pond							**35**	**152**	**413**					
Pah Wah Pond	Lockwood	32 Pah Wah Pond	1,230	Lockwood	30	5 to 15	35	152		0.12	**5**	$1,512,900	d with Namequoit PRB	Upper Reach Priority embayment
Quanset and Pleasant Bay Main Basin							**122**	**531**	**1485**					
Quanset and Pleasant Bay Main Basin	Quonset 1,2,3	33, 37 Pleasant Bay and Quanset Pond	1,745	Towhee, Lake Dr, Oyster	30	10 to 40	43	187		0.11	**7**	$2,146,350	$5,071,900	Upper Reach Priority embayment
Quanset and Pleasant Bay Main Basin	Grannys	33, 37 Pleasant Bay and Quanset Pond	650	Grannys Ln	30	15 to 20	24	104		0.16	**4**	$799,500	$2,174,200	Upper Reach Priority embayment
Quanset and Pleasant Bay Main Basin	Winslow	33, 37 Pleasant Bay and Quanset Pond	1,150	Winslow Dr and Way	30	5 to 40	14	61		0.05	**14**	$1,414,500	$3,496,900	Upper Reach Priority embayment
Quanset and Pleasant Bay Main Basin	Richwood	33, 37 Pleasant Bay and Quanset Pond	890	Richwood Farm	30	10 to 15	41	178		0.20	**2**	$1,094,700	$2,805,100	Upper Reach Priority embayment
Pochet							**171**	**744**	**1,564**					
Pochet	Duck Hole	35 Pochet Neck Stream	4,100	High View, Old Duck Hole, Lovell	30	5 to 35	68	296		0.07	**12**	$5,043,000	$11,335,800	Upper Reach Priority embayment
Pochet	Gosnold	34, 35 Pochet and Pochet Neck Stream	2,081	Gosnold,	30	10 to 30	29	126		0.06	**13**	$2,559,630	$5,966,700	Upper Reach Priority embayment
Pochet	Briar Spring	34 Pochet	2,906	Briar Spring	30	10 to 35	59	257		0.09	**10**	$3,574,380	$8,168,400	Upper Reach Priority embayment
Pochet	Blossom	35 Pochet	400	Blossom , Sparrowhawk	30	30 to 40	15	65		0.16	**3**	$492,000	$1,513,400	Upper Reach Priority embayment
Pleasant Bay Estuary (Orleans)			**21,237**				**486**	**2,115**	**4,966**			**$26,121,510**	**$61,744,400**	
	Average Efficiency kg/LF/yr									**0.10**				

Nauset Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	Length (ft)	Roads	Saturated Depth (ft)	Depth Range to GW (ft)	Estimated Parcels	Estimated Sewer Load reduced (kg/yr) at 80% PRB Efficiency	Embayment Non-Traditional Technology Goal (kg/yr)	Estimated kg/LF/yr	Pleasant Bay Watershed PRB kg/yr Efficincy Rank	PRB Installation Cost Estimate	30-year LCCA for PRB (Present Worth)	Evaluation Notes
Town Cove							**171**	**744**	**566**					
Town Cove	Tonset	5 Town Cove	7,300	Gibson, Tonset	30	10 to 30	93	405		0.06	**3**	$8,979,000	$22,059,000	Upper Reach Priority embayment
Town Cove	Main	5 Town Cove	850	Main	40	5 to 10	78	339		0.40	**2**	$1,045,500	luded with Tonset PRB	Upper Reach Priority embayment
Mill Pond							**28**	**122**						
Mill Pond	Norseman	8 Mill Pond	580	Norsemans Road, Mill Pond Rd	40	10 to 35	28	122		0.21	**1**	$713,400	$1,999,700	Upper Reach Priority embayment
Nauset Estuary (Orleans)			**8,730**				**199**	**866**				**$10,737,900**	**$24,058,700**	
	Average Efficiency kg/LF/yr									**0.22**				

Rock Harbor Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	Length (ft)	Roads	Saturated Depth (ft)	Depth Range to GW (ft)	Estimated Parcels	Estimated Sewer Load reduced (kg/yr) at 80% PRB Efficiency	Embayment Non-Traditional Technology Goal (kg/yr)	Estimated kg/LF/yr	Pleasant Bay Watershed PRB kg/yr Efficincy Rank	PRB Installation Cost Estimate	30-year LCCA for PRB (Present Worth)	Evaluation Notes
Rock Harbor Main	**Rock Harbor**						**70**	**305**	**634**					
Rock Harbor	Rock Harbor	3 Rock Harbor Main	3,940	Rock Harbor	50	5 to 15	70	305		0.08	1	$103,425	$10,896,700	Upper Reach Priority embayment
Rock Harbor Estuary (Orleans)	**Rock Harbor**		**3,940**				**70**	**305**	**634**	**0.08**		**$4,846,200**	**$10,896,700**	

PRB Townwide Potential Total			**33,907**				**755**	**3,286**				**$41,705,610**	**$96,699,800**	

Table 2
Orleans PRB Selection Matrix - PRB Characteristics

Pleasant Bay Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	Roads	Saturated Thickness of PRB (ft)	Depth Range to Groundwater (ft)
Meeting House Pond	None					
Lonnies Pond/ Kescayo Gansett River						
Lonnies Pond/Kescayo Gansett River	Monument	25, 26 Lonnies Pond/Kescayo Gansett River	1,675	Monument	30	25 to 50
Aerys Pond	None					
Upper River						
Upper River	Keziahs	41 Upper River	1,250	Keziahs	30	15 to 40
Lower River						
Lower River	Mayflower	28 Lower River	1,700	Pershing, Kenneth	30	10 to 30
Namequoit River						
Namequoit River	Namequoit	30 Namequoit River	1,000	Namequoit Road	30	10 to 40
Namequoit River	Ridge	30 Namequoit River	460	Ridgewood Rd	30	10 to 30
Pah Wah Pond						
Pah Wah Pond	Lockwood	32 Pah Wah Pond	1,230	Lockwood	30	5 to 15
Quanset and Pleasant Bay Main Basin						
Quanset and Pleasant Bay Main Basin	Quonset 1,2,3	33, 37 Pleasant Bay and Quanset Pond	1,745	Towhee, Lake Dr, Oyster	30	10 to 40
Quanset and Pleasant Bay Main Basin	Grannys	33, 37 Pleasant Bay and Quanset Pond	650	Grannys	30	15 to 20
Quanset and Pleasant Bay Main Basin	Winslow	33, 37 Pleasant Bay and Quanset Pond	1,150	Winslow Dr and Way	30	5 to 40
Quanset and Pleasant Bay Main Basin	Richwood	33, 37 Pleasant Bay and Quanset Pond	890	Richwood Farm	30	10 to 15
Pochet						
Pochet	Duck Hole	35 Pochet Neck Stream	4,100	High View, Old Duck Hole, Lovell	30	5 to 35
Pochet	Gosnold	34, 35 Pochet and Pochet Neck Stream	2,081	Gosnold,	30	10 to 30
Pochet	Briar Spring	34 Pochet	2,906	Briar Spring	30	10 to 35
Pochet	Blossom	34 Pochet	400	Blossom , Sparrowhawk	30	30 to 40
Pleasant Bay Estuary (Orleans)			**21,237**			

Nauset Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	Roads	PRB Saturated Thickness (ft)	Depth Range to Groundwater (ft)
Town Cove						
Town Cove	Tonset	5 Town Cove	7,300	Gibson, Tonset	30	10 to 30
Town Cove	Main	5 Town Cove	850	Main	40	5 to 10
Mill Pond						
Mill Pond	Norseman	8 Mill Pond	580	Norsemans Road, Mill Pond Rd	40	10 to 35
Nauset Estuary (Orleans)			**8,730**			

Rock Harbor Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	Roads	PRB Saturated Thickness (ft)	Depth Range to Groundwater (ft)
Rock Harbor Main	Rock Harbor					
Rock Harbor	Rock Harbor	3 Rock Harbor Main	3,940	Rock Harbor	50	5 to 15
Rock Harbor Estuary (Orleans)	Rock Harbor		**3,940**			

PRB Townwide Potential Total			**33,907**			

Table 3
Orleans PRB Selection Matrix - Effectiveness

Pleasant Bay Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	Estimated Number of Parcels	Estimated Sewer Load reduced (kg/yr) at 80% PRB Efficiency	Embayment Non-Traditional Technology Goal (kg/yr)	Percentage Removed	Estimated PRB Efficiency (kg/LF/yr)	PRB Watershed Efficincy Rank (kg/yr)	Evaluation Notes
Meeting House Pond	None			**0**	**0**	**40**	**0**			Traditional Technology to be Used
Lonnies Pond/Kescayo Gansett River				**41**	**178**	**284**	**63**			
Lonnies Pond/Kescayo Gansett River	Monument	Gansett River	1,675	41	178			0.11	**8**	Upper Reach Priority embayment
Aerys Pond	None			**0**	**0**	**113**	**0**			
Upper River				**26**	**113**	**202**	**56**			
Upper River	Keziahs	41 Upper River	1,250	26	113			0.09	**9**	Upper Reach Priority embayment
Lower River				**35**	**152**	**517**	**29**			
Lower River	Mayflower	28 Lower River	1,700	35	152			0.09	**11**	Upper Reach Priority embayment
Namequoit River				**56**	**244**	**348**	**70**			
Namequoit River	Namequoit	30 Namequoit River	1,000	27	117			0.12	**6**	Upper Reach Priority embayment
Namequoit River	Ridge	30 Namequoit River	460	29	126			0.27	**1**	Upper Reach Priority embayment
Pah Wah Pond				**35**	**152**	**413**	**37**			
Pah Wah Pond	Lockwood	32 Pah Wah Pond	1,230	35	152			0.12	**5**	Upper Reach Priority embayment
Quanset and Pleasant Bay Main Basin				**122**	**531**	**1,485**	**36**			
Quanset and Pleasant Bay Main Basin	Quonset 1,2,3	Pond	1,745	43	187			0.11	**7**	Upper Reach Priority embayment
Quanset and Pleasant Bay Main Basin	Grannys	Pond	650	24	104			0.16	**4**	Lower Priority
Quanset and Pleasant Bay Main Basin	Winslow	Pond	1,150	14	61			0.05	**14**	Lower Priority
Quanset and Pleasant Bay Main Basin	Richwood	Pond	890	41	178			0.20	**2**	Lower Priority
Pochet				**171**	**744**	**1,564**	**48**			
Pochet	Duck Hole	35 Pochet Neck Stream	4,100	68	296			0.07	**12**	Upper Reach Priority embayment
Pochet	Gosnold	Stream	2,081	29	126			0.06	**13**	Upper Reach Priority embayment
Pochet	Briar Spring	34 Pochet	2,906	59	257			0.09	**10**	Upper Reach Priority embayment
Pochet	Blossom	35 Pochet	400	15	65			0.16	**3**	Upper Reach Priority embayment
Pleasant Bay Estuary (Orleans)			**21,237**	**486**	**2,115**	**4,966**	**43**			

Nauset Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	Estimated Number of Parcels	Estimated Sewer Load reduced (kg/yr) at 80% PRB Efficiency	Embayment Non-Traditional Technology Goal (kg/yr)	Percentage Removed	Estimated PRB Efficiency (kg/LF/yr)	PRB Watershed Efficincy Rank (kg/yr)	Evaluation Notes
Town Cove				**171**	**744**	**566**	**131**			
Town Cove	Tonset	5 Town Cove	7,300	93	405			0.06	**3**	Upper Reach Priority embayment
Town Cove	Main	5 Town Cove	850	78	339			0.40	**1**	Upper Reach Priority embayment
Mill Pond				**28**	**122**	**0**				
Mill Pond	Norseman	8 Mill Pond	580	28	122			0.21	**2**	Lower Priority
Nauset Estuary (Orleans)			**8,730**	**199**	**866**	**566**	**153**			

Rock Harbor Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	Estimated Number of Parcels	Estimated Sewer Load reduced (kg/yr) at 80% PRB Efficiency	Embayment Non-Traditional Technology Goal (kg/yr)	Percentage Removed	Estimated PRB Efficiency (kg/LF/yr)	PRB Watershed Efficincy Rank (kg/yr)	Evaluation Notes
Rock Harbor Main	**Rock Harbor**			**70**	**305**	**634**	**48**			
Rock Harbor	Rock Harbor	3 Rock Harbor Main	3,940	70	305			0.08	**1**	Upper Reach Priority embayment
Rock Harbor Estuary (Orleans)	**Rock Harbor**		**3,940**	**70**	**305**	**634**	**48**			

PRB Townwide Potential Total			**33,907**	**755**	**3,286**					

Table 4
Orleans PRB Selection Matrix - Cost

Orleans Potential Full Scale PRBs - Pleasant Bay

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	PRB Installation Cost Estimate (Using Avg. $/LF)	30-year LCCA for PRB	60-year LCCA for PRB	100-year LCCA for PRB
Meeting House Pond	None						
Lonnies Pond/Kescayo Gansett River							
Lonnies Pond/Kescayo Gansett River	Monument	25, 26 Lonnies Pond/Kescayo Gansett River	1,675	$2,060,250	$4,889,900	$11,771,500	$29,263,500
Aerys Pond	None						
Upper River							
Upper River	Keziahs	41 Upper River	1,250	$1,537,500	$3,775,700	$9,105,000	$22,593,400
Lower River							
Lower River	Mayflower	28 Lower River	1,700	$2,091,000	$4,969,200	$11,956,900	$29,715,300
Namequoit River							
Namequoit River	Namequoit	30 Namequoit River	1,000	$1,230,000	$7,577,200	$18,219,500	$45,400,700
Namequoit River	Ridge	30 Namequoit River	460	$565,800	Included with Namequoit PRB		
Pah Wah Pond							
Pah Wah Pond	Lockwood	32 Pah Wah Pond	1,230	$1,512,900	Included with Namequoit PRB		
Quanset and Pleasant Bay Main Basin							
Quanset and Pleasant Bay Main Basin	Quonset 1,2,3	33, 37 Pleasant Bay and Quanset Pond	1,745	$2,146,350	$5,071,900	$12,209,000	$30,358,200
Quanset and Pleasant Bay Main Basin	Grannys	33, 37 Pleasant Bay and Quanset Pond	650	$799,500	$2,174,200	$5,274,000	$13,024,100
Quanset and Pleasant Bay Main Basin	Winslow	33, 37 Pleasant Bay and Quanset Pond	1,150	$1,414,500	$3,496,900	$8,444,200	$20,954,000
Quanset and Pleasant Bay Main Basin	Richwood	33, 37 Pleasant Bay and Quanset Pond	890	$1,094,700	$2,805,100	$6,785,400	$16,804,500
Pochet							
Pochet	Duck Hole	35 Pochet Neck Stream	4,100	$5,043,000	$11,335,800	$27,203,000	$67,830,500
Pochet	Gosnold	34, 35 Pochet and Pochet Neck Stream	2,081	$2,559,630	$5,966,700	$14,355,900	$35,730,300
Pochet	Briar Spring	34 Pochet	2,906	$3,574,380	$8,168,400	$19,624,000	$48,891,500
Pochet	Blossom	35 Pochet	400	$492,000	$1,513,400	$3,693,000	$9,072,400
Pleasant Bay Estuary (Orleans)			**21,237**	**$26,121,510**	**$61,744,400**	**$148,641,400**	**$369,638,400**

Orleans Potential Full Scale PRBs - Nauset Estuary

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	PRB Installation Cost Estimate (Using Avg. $/LF)	30-year LCCA for PRB	60-year LCCA for PRB	100-year LCCA for PRB
Town Cove							
Town Cove	Tonset	5 Town Cove	7,300	$8,979,000	$22,059,000	$52,885,100	$132,049,100
Town Cove	Main	5 Town Cove	850	$1,045,500	Included with Tonset PRB		
Mill Pond							
Mill Pond	Norseman	8 Mill Pond	580	$713,400	$1,999,700	$4,855,300	$11,973,500
Nauset Estuary (Orleans)			**8,730**	**$10,737,900**	**$24,058,700**	**$57,740,400**	**$144,022,600**

Orleans Potential Full Scale PRBs - Rock Harbor

Embayment	PRB Name	MEP Watershed ID	PRB Length (ft)	PRB Installation Cost Estimate (Using Avg. $/LF)	30-year LCCA for PRB	60-year LCCA for PRB	100-year LCCA for PRB
Rock Harbor Main	**Rock Harbor**						
Rock Harbor	Rock Harbor	3 Rock Harbor Main	3,940	$4,846,200	$10,896,700	$26,158,100	$65,232,700
Rock Harbor Estuary (Orleans)			**3,940**	**$4,846,200**	**$10,896,700**	**$26,158,100**	**$65,232,700**

PRB Townwide Potential Total			**33,907**	**$41,705,610**	**$96,699,800**	**$232,539,900**	**$578,893,700**

Table 5
Orleans Traditional Costs for Potential Full Scale PRB Areas

Orleans Traditional Costs for Potential Full Scale PRBs - Pleasant Bay

Embayment	PRB Name	Number of Parcels	Gravity Sewer (LF)	Low-Pressure Sewer (LF)	Pumping Station	Force Main (LF)	Highway Crossing	30-year LCCA for Traditional Treatment of PRB Area	60-year LCCA for Traditional Treatment of PRB Area	100-year LCCA for Traditional Treatment of PRB Area
Meeting House Pond	None									
Lonnies Pond/Kescayo Gansett River										
Lonnies Pond/Kescayo Gansett River	Monument	56	-	5,100	1	2,800	-	$11,229,800	$15,734,500	$27,359,400
Aerys Pond	None									
Upper River										
Upper River	Keziahs	38	-	4,620	1	1,050	0	$10,035,300	$14,393,400	$25,650,700
Lower River										
Lower River	Mayflower	39	-	6,120	1	2,400	-	$12,765,500	$18,543,100	$33,692,900
Namequoit River										
Namequoit River	Namequoit	112	-	12,030	1	2,330	-	$19,643,800	$29,703,600	$56,663,500
Namequoit River	Ridge	Included with Namequoit PRB								
Pah Wah Pond										
Pah Wah Pond	Lockwood	Included with Namequoit PRB								
Quanset and Pleasant Bay Main Basin										
Quanset and Pleasant Bay Main Basin	Quonset 1,2,3	48	-	7,370	1	6,925	-	$15,991,500	$22,244,300	$38,615,600
Quanset and Pleasant Bay Main Basin	Grannys	34	-	3,650	1	4,200	-	$10,881,800	$15,022,900	$25,634,900
Quanset and Pleasant Bay Main Basin	Winslow	33	-	3,100	1	1,100	-	$8,991,300	$12,956,400	$23,135,400
Quanset and Pleasant Bay Main Basin	Richwood	57	-	5,000	1	-	-	$11,027,600	$16,752,400	$31,824,500
Pochet										
Pochet	Duck Hole	49	-	12,240		-	-	$13,930,300	$22,394,800	$45,712,100
Pochet	Gosnold	43	-	5,250	1	1,450	-	$10,909,800	$15,672,600	$28,034,500
Pochet	Briar Spring	65	-	7,855	1	2,000	-	$14,027,700	$20,485,700	$37,516,300
Pochet	Blossom	22	-	1,925	1	1,350	-	$7,749,600	$10,875,800	$18,740,100
Pleasant Bay Estuary (Orleans)								**$147,184,000**	**$214,779,500**	**$392,579,900**

Orleans Traditional Costs for Potential Full Scale PRBs - Nauset Estuary

Embayment	PRB Name	Number of Parcels	Gravity Sewer (LF)	Low-Pressure Sewer (LF)	Pumping Station	Force Main (LF)	Highway Crossing	30-year LCCA for Traditional Treatment of PRB Area	60-year LCCA for Traditional Treatment of PRB Area	100-year LCCA for Traditional Treatment of PRB Area
Town Cove										
Town Cove	Tonset	229	11,000	9,850	1	3,500	-	$38,691,600	$57,626,500	$109,101,700
Town Cove	Main	Included with Tonset PRB								
Mill Pond										
Mill Pond	Norseman	37	-	3,200	1	7,000	-	$12,338,300	$16,772,700	$28,160,100
Nauset Estuary (Orleans)								**$51,029,900**	**$74,399,200**	**$137,261,800**

Orleans Traditional Costs for Potential Full Scale PRBs - Rock Harbor

Embayment	PRB Name	Number of Parcels	Gravity Sewer (LF)	Low-Pressure Sewer (LF)	Pumping Station	Force Main (LF)	Highway Crossing	30-year LCCA for Traditional Treatment of PRB Area	60-year LCCA for Traditional Treatment of PRB Area	100-year LCCA for Traditional Treatment of PRB Area
Rock Harbor Main	**Rock Harbor**									
Rock Harbor	Rock Harbor	81	0	8200	0	0	1	$10,994,600	$17,218,300	$34,367,700
Rock Harbor Estuary (Orleans)								**$10,994,600**	**$17,218,300**	**$34,367,700**

Traditional Costs for PRB Townwide Potential Total								**$209,208,500**	**$306,397,000**	**$564,209,400**

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Figures

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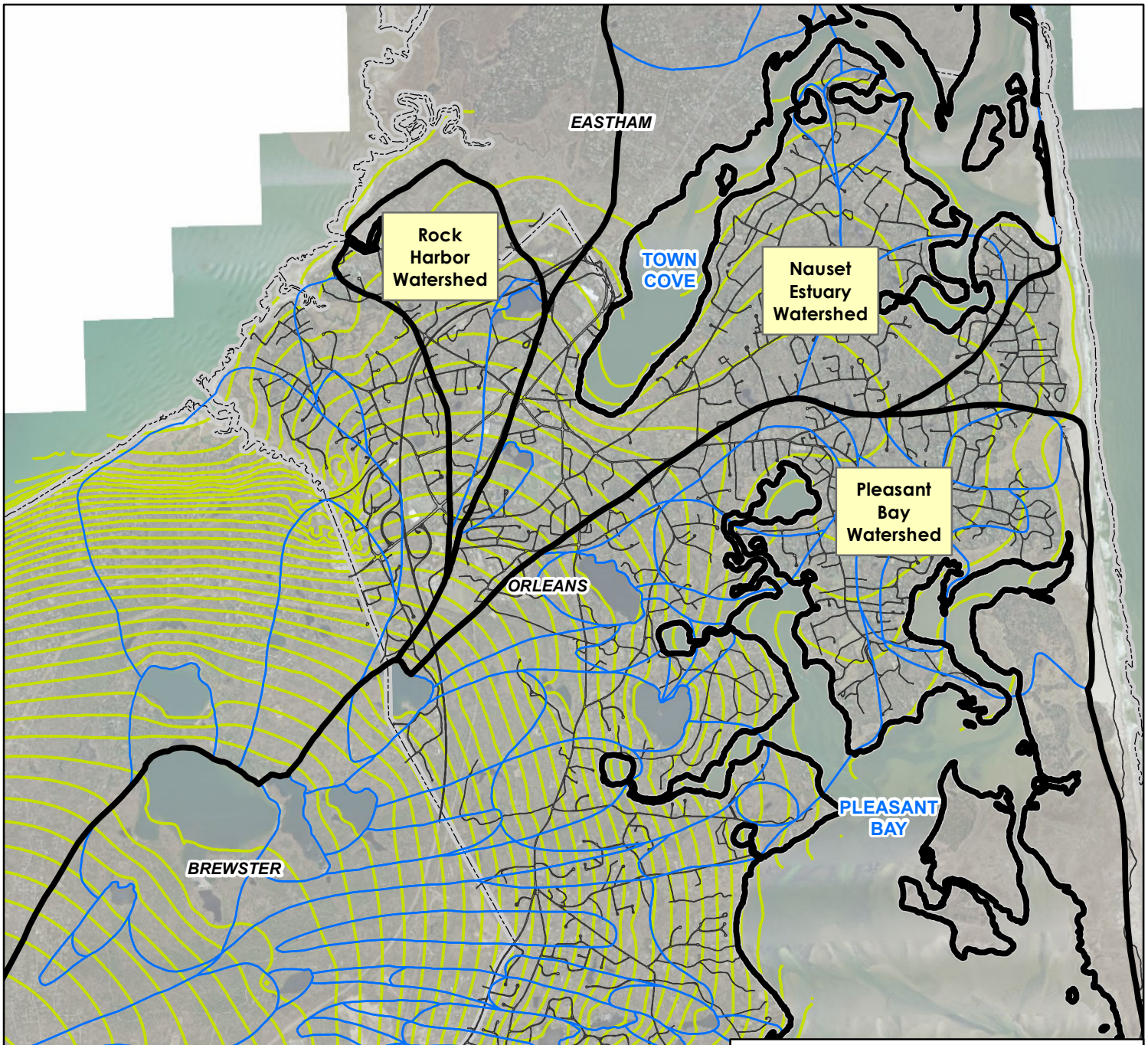


FIGURE 1

TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING

MAJOR AND SUB-WATERSHEDS

Legend

- Groundwater Contour
- Edge of Pavement
- MEP Subwatershed
- Town Boundary

1 inch = 4,000 feet

0 2,500 5,000 Feet

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FIGURE 2
PARTICLE TRACKING

TOWN OF ORLEANS
MASSACHUSETTS

AUGUST 2020

N

0 600 1,200 2,400 3,600 4,800
Feet

Rock Harbor PRB
Rock Harbor
Little Namskaket
Cedar Pond
Rock Harbor Watershed
Namskaket
Tonset PRB
Town Cove
Nauset Estuary Watershed
Norseman PRB
Mill Pond
Main St PRB
Pleasant Bay Watershed
Duck Hole PRB
Gosnold PRB
Meetinghouse Pond
Uncle Harvey's Pond
Blossom PRB
Briar Spring PRB
Pochet
Crystal Lake
Keziah's PRB
Upper River
Lonies Pond
Monument PRB
Mayflower PRB
Baker's Pond
Pilgrim Lake
Lower River
Namequoit River
Arey's Pond
Namequoit PRB
Ridge PRB
Lockwood PRB
Richwood PRB
Grannys PRB
Uncle Israel's Pond
Twinings Pond
Sarah's Pond
Shoal Pond
Meadow Bog Pond
Deep Pond
Quanset 3 PRB
Quanset
Quanset 2 PRB
Quanset 1 PRB
Winslow PRB
LITTLE PLEASANT BAY
HARWICH
PLEASANT BAY
CHATHAM

Legend

- Permeable Reactive Barrier
- Paths
- MEP Subwatershed
- Potable Well
- Potential Potable Well - VERIFY
- 208_Embayments
- Parcel with PRB (755)
- Other Parcels (4,705)

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Appendix A: Implementation Plan for Full-Scale PRBs

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AECOM
9 Jonathan Bourne Drive
Pocasset, MA 02559
www.aecom.com

508.833.6950 tel
508.833.6951 fax

Memorandum

To	George Meservey, Director of Planning & Community Development
CC	Betsy Shreve, AICP, AECOM Project Director James Begley, LSP, MT Environmental AECOM PRB Team
Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task 11.1.B.2 - Permeable Reactive Barriers (PRB)** **Implementation Plan for Full-Scale PRBs - Final**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	August 6, 2018

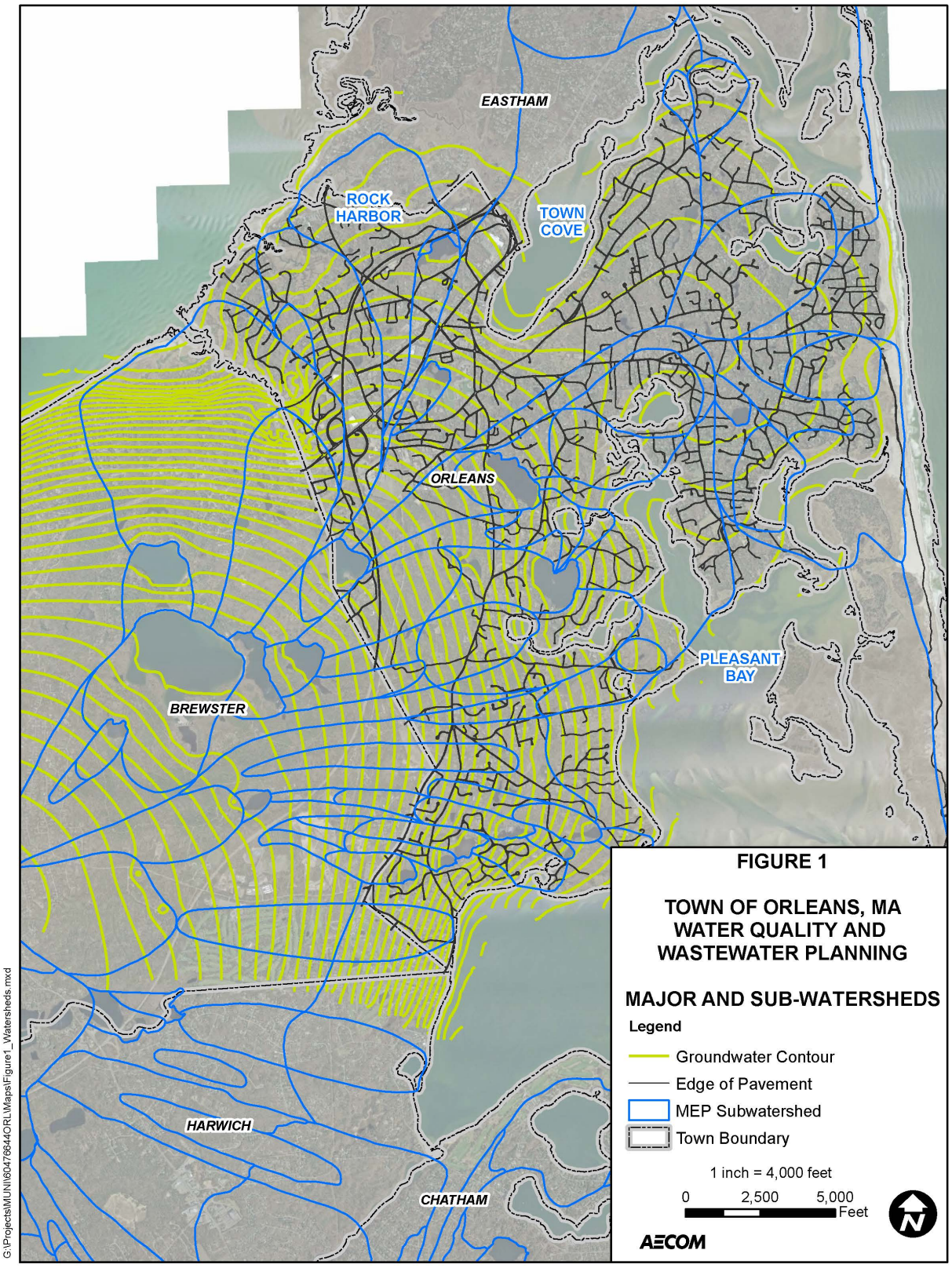
Approvals	Date	Signature / Initials
George Meservey, Orleans, MA Director of Planning & Community Development		

1. Introduction

This full-scale Permeable Reactive Barrier (PRB) Implementation Plan has been developed on behalf of the Town of Orleans Massachusetts (the Town) and includes preliminary design information and planning steps necessary for successful application of PRBs to reduce nitrogen loading to estuaries in Orleans. The estuaries include Rock Harbor, Nauset Estuary, and Pleasant Bay with proposed PRB systems in their respective watersheds. The PRBs will treat watershed nitrate prior to discharge to surface waters and be located to provide the most cost-effective treatment. The objective of this Implementation Plan is to provide preliminary design information and identify actions necessary to permit and install the PRBs and achieve verified nitrogen reductions. This plan identifies several potential PRB locations, but final locations will be selected after assessment of potential sites and public input on the proposed locations.

2. Background

Major watersheds in the Town include Nauset Harbor and Pleasant Bay sub-watersheds within the Atlantic Ocean watershed, and Namskaket Creek, Little Namskaket Creek, and Rock Harbor sub-watersheds within the Cape Cod Bay watershed. The groundwater system comprising these watersheds is part of the Monomoy Lens of the Cape Cod Aquifer. These major watersheds are characterized by numerous sub-watersheds contributing groundwater discharge to freshwater ponds, and estuaries including bays, salt ponds, and inlets as shown in Figure 1. Nitrogen in the form of nitrate, mainly from septic systems and fertilizer use is released to groundwater in the watersheds and then moves as a large dilute plume with groundwater flow and eventually discharges to the estuaries and coastal waters. This groundwater source of nitrogen is combined with additional sources such as stormwater runoff and fertilizer resulting in significant nitrogen loading to the surface water. When nitrogen loading reaches a certain threshold, it causes eutrophication or over enrichment of nutrients in estuaries resulting in algae blooms, scum layers, unpleasant odors, and periodic fish kills due to low oxygen conditions.


EASTHAM
ROCK HARBOR
TOWN COVE
ORLEANS
PLEASANT BAY
BREWSTER
HARWICH
CHATHAM
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FIGURE 1
TOWN OF ORLEANS, MA
WATER QUALITY AND
WASTEWATER PLANNING
MAJOR AND SUB-WATERSHEDS
Legend
Groundwater Contour
Edge of Pavement
MEP Subwatershed
Town Boundary
1 inch = 4,000 feet
0
2,500
5,000
Feet
AECOM

To address these concerns and comply with the Clean Water Act, the Town prepared a Comprehensive Wastewater Management Plan (CWMP) in December 2010. In response to comments on the CWMP, the Town re-evaluated its previously recommended approach to nitrogen control, which focused on installation of an extensive sewage collection system and new treatment facility with discharge at the Tri-Town Septage Treatment Facility site.

Subsequently, a draft Amended Comprehensive Wastewater Management Plan (ACWMP) was developed to document proposed changes including a revised Hybrid Plan. The ACWMP was developed in accordance with the Cape Cod 208 Water Quality Plan, which has been approved by both the United States Environmental Protection Agency (US EPA) and the Massachusetts Department of Environmental Protection (MassDEP).

The 25 percent Preliminary Design Report (PDR) plans for sewers in two areas including approximately 330 parcels encompassing the Downtown Area and approximately 406 parcels within the Meetinghouse Pond Area.

As this time, the revised ACWMP Hybrid Plan also included provisions for use of non-traditional technologies including PRBs and shellfish propagation to control nitrogen including an ongoing aquaculture demonstration in Lonnies Pond. Demonstrations for both PRBs and shellfish propagation are currently underway. Using these non-traditional technologies allows for reduced sewer collection system coverage while still achieving nitrogen control objectives. Permeable Reactive Barriers (PRBs) provide a way to intercept nitrogen in groundwater at key locations in the watersheds before it reaches sensitive embayments.

A PRB Demonstration Test has been implemented at the Eldredge Park Way location in Orleans to assess feasibility, determine PRB nitrogen removal efficiency, and assess the environmental sustainability of the alternative. The demonstration project was implemented in November 2016, was expanded in June 2018 and is subject to an intensive ongoing monitoring program to quantify nitrogen removal and secondary water quality effects. The cost for the three year demonstration test (investigations, implementation, expansion and monitoring) is approximately $917,000. Preliminary monitoring data indicate that the PRB is serving to reduce nitrogen concentrations in groundwater without significant secondary water quality impacts. Information gained through the demonstration will be utilized in determining final engineering details for full-scale implementation, refining monitoring plans, and predicting nitrogen removal efficiency for cost effectively achieving water quality goals.

3. Permeable Reactive Barrier Technology

A PRB is a passive treatment technology, designed in this application to in tercept and treat nitrate in groundwater through biological denitrification before the groundwater reaches downgradient surface waters. The PRB treatment zone is installed in the groundwater saturated zone below the water table, where amendments are added by injection to form the PRB. PRBs are typically oriented perpendicular to the direction of groundwater flow as shown in Figure 2 and rely on the natural groundwater gradient to carry nitrate to the PRB. The system is permeable because the injected amendments are designed not to interfere with groundwater flow, only removing nitrate as the groundwater passes through.

Key Terms

Permeable Reactive Barrier (PRB)
A zone of enhanced denitrification formed in the path of a dissolved nitrate plume.

Denitrification
Biological conversion of nitrate in water to inert nitrogen gas by naturally occurring bacteria. Denitrification: $NO_3^- \rightarrow N_2$ (gas)

PRB Amendment
Emulsified vegetable oil (EVO) used to provide dissolve organic carbon to stimulate naturally occurring bacteria in groundwater to transform nitrate to inert nitrogen gas.

Preliminary Design
Provides a concept with typical layout, materials, and steps to install the PRBs and associated cost elements.

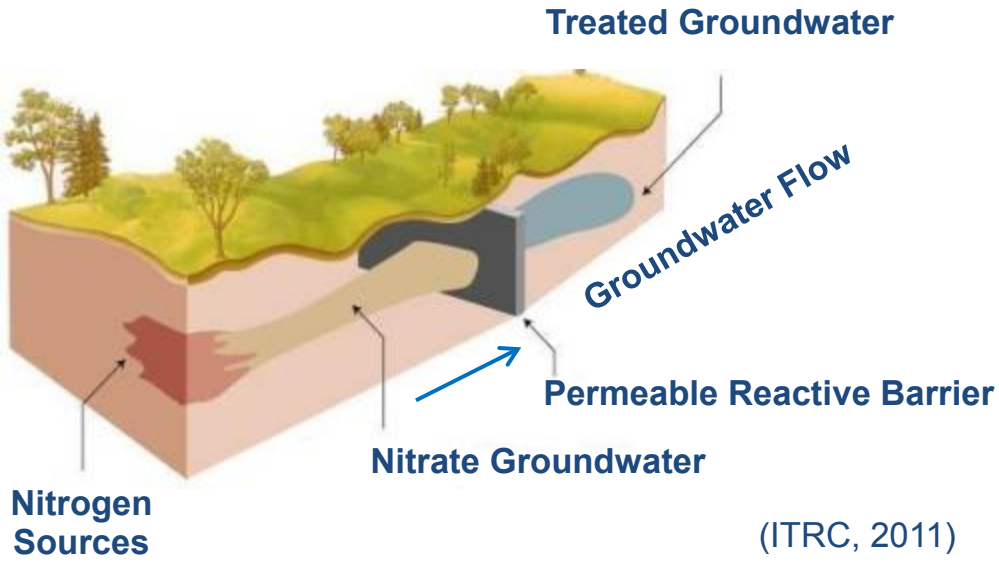


Figure 2 - Permeable Reactive Barrier

The injected amendment used to form the PRB is typically emulsified vegetable oil (EVO), a source of dissolved organic carbon that stimulates naturally occurring microbes in the groundwater to consume the dissolved organic carbon while respiring oxygen and creating anoxic conditions (without oxygen) favorable for denitrifying bacteria. The denitrifying bacteria then continue to use the dissolved organic carbon while respiring nitrate. This process of bacterial metabolism results in the conversion of nitrate to inert nitrogen gas. The PRB will need to be rejuvenated with additional EVO injections following an extended period of operation to replenish the consumed organic carbon.

4. Water Quality Goals

A. General

Development of surface water quality goals in the form of Total Maximum Daily Loads (TMDLs) is required by the Federal Clean Water Act. To develop embayment specific TMDLs, the Massachusetts Estuaries Project (MEP) have assessed nitrogen loading to the estuaries using an analytical method called the Linked Watershed-Embayment Management Modeling Approach. The model links watershed nitrogen inputs with surface water circulation and nitrogen characteristics. The TMDLs define the maximum nitrogen loads that the water bodies can receive while still meeting necessary water quality criteria. Corrective actions are then necessary to reduce nitrogen loading to below the TMDLs.

TMDLs developed by MEP have been documented in technical reports prepared for Pleasant Bay, Rock Harbor, and the Nauset Estuary (MEP 2006, MEP 2007, MEP 2012). Based on the TMDLs developed by the MEP, the MassDEP and US EPA have approved nitrogen TMDLs for Pleasant Bay. Additional TMDLs are undergoing review by the regulatory agencies. MEP assessments of Namskaket and Little Namskaket Creeks indicated no exceedances of developed TMDLs.

B. Pleasant Bay TMDLs

Pleasant Bay is connected to the Atlantic Ocean and is characterized by three main basins including Little Pleasant Bay, Pleasant Bay, and Chatham Harbor. The bay has a long shoreline and numerous sub-embayments. These sub-embayments are at particular risk of eutrophication from high nitrogen loads entering by direct groundwater discharge and restricted tidal exchange. Main basins in or adjacent to Orleans include Pleasant Bay Main Basin and Little Pleasant Bay. The sub-embayments in Orleans include Meetinghouse Pond, the Upper and Lower River, Lonnies Pond, Namequoit River and Aries Pond, Paw Wah Pond, Quanset Pond, and Pochet Inlet.

MEP issued the report "Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Pleasant Bay System, Orleans, Chatham, Brewster and Harwich, Massachusetts" in May 2006 that included proposed TMDLs for the system. On June 23, 2017 the Select Boards of Brewster, Chatham, Harwich and Orleans voted to sign a Resolution of the Towns sharing the Watershed of Pleasant Bay, endorsing the Pleasant Bay Composite Nitrogen Management Analysis as an accurate representation of each Town's share of current attenuated nitrogen load and its responsibility to remove nitrogen in Pleasant Bay (Pleasant Bay Alliance, March 2017). The agreed Town of Orleans share of attenuated Pleasant Bay Watershed nitrogen load is 6,980 kg/yr. The Towns sharing the watershed of Pleasant Bay entered an inter-municipal memorandum of agreement in 2018 to coordinate resource management of Pleasant Bay among the member Towns through the Pleasant Bay Alliance. The Pleasant Bay Alliance developed nitrogen removal requirements by Town and by Sub-embayment identifying these requirements is shown on Table 1 (Pleasant Bay Alliance March 2017).

C. Nauset Harbor Embayment System TMDLs

The Nauset Harbor Embayment System in Orleans and Eastham is comprised of open waters including Nauset Harbor and Town Cove, Nauset Marsh, located behind Nauset Barrier Beach, and three sub-embayments including Salt Pond, Wood Cove, and Mill Pond. The Nauset Harbor Estuary watershed is in the Towns of Orleans, Eastham, and Brewster. The most impacted areas with impaired habitat, and therefore the focus of nitrogen load reduction in Orleans, include the upper reach at Town Cove and the semi-enclosed Mill Pond and Wood Cove sub-embayments. The Salt Pond sub-embayment in Eastham is also at risk of eutrophication. MEP issued the report "Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Nauset Harbor Embayment System, Towns of Orleans and Eastham, Massachusetts" in 2012 that included TMDLS for the estuary.

Based on the draft ACWMP, the required nitrogen removal by Orleans for the Nauset system is 5,442 kg/yr, with a PRB technology removal target of 566 kg/yr focused on Town Cove.

D. Rock Harbor TMDLs

The watershed for Rock Harbor is in the Towns of Orleans and Eastham. Rock Harbor is a man-made harbor at the mouth of a tidal river and salt marsh and opens to Cape Cod Bay to the north. Significant habitat quality impairment and the presence of algal mats have been observed in the lower reach harbor area, while the upper reach marsh area has higher quality habitat. MEP issued the report "Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Rock Harbor Embayment System, Towns of Orleans, Massachusetts" in December 2008 that included TMDLs for the estuary.

Based on the draft ACWMP, the required nitrogen removal by Orleans for Rock Harbor is 1,463 kg/yr, with a PRB technology removal target of 634 kg/yr.

Table 1 - Pleasant Bay Composite Nitrogen Management Analysis
Nitrogen Removal Requirements by Town and by Sub-embayment (kg/yr)
(Pleasant Bay Alliance March 2017)

Pleasant Bay Composite Nitrogen Management Analysis

Table 1. Nitrogen Removal Requirements by Town and by Subembayment (kg/yr)

Subembayment	Brewster	Chatham	Harwich	Orleans	Total
Meetinghouse Pond				1,876	1,876
Town Percent of Total Removal				100%	100%
Lonnies Pond	14			284	298
Town Percent of Total Removal	5%			95%	100%
Areys Pond	29			113	142
Town Percent of Total Removal	20%			80%	100%
The River - Upper	3			375	378
Town Percent of Total Removal	1%			99%	100%
The River - Lower	6			518	524
Town Percent of Total Removal	1%			99%	100%
Namequoit River	19			348	367
Town Percent of Total Removal	5%			95%	100%
Paw Wah Pond				413	413
Town Percent of Total Removal				100%	100%
Quanset Pond	29			227	256
Town Percent of Total Removal	11%			89%	100%
Round Cove	1		1,209		1,210
Town Percent of Total Removal	0.1%		99.9%		100%
Muddy Creek Upper		193	584		777
Town Percent of Total Removal		25%	75%		100%
Muddy Creek Lower		584	986		1,570
Town Percent of Total Removal		37%	63%		100%
Ryder's Cove		1,954			1,954
Town Percent of Total Removal		100%			100%
Crows Pond		0			0
Town Percent of Total Removal		-			-
Bassing Harbor		0			0
Town Percent of Total Removal		-			-
Frost Fish Creek		803			803
Town Percent of Total Removal		100%			100%
Pochet				1,569	1,569
Town Percent of Total Removal				100%	100%
Pleasant Bay (including Little Pleasant Bay)	2,161	542	1,620	1,257	5,580
Town Percent of Total Removal	39%	10%	29%	22%	100%
Chatham Harbor		0			0
Town Percent of Total Removal		-			-
Total (All Subembayments)	2,262	4,076	4,399	6,980	17,717
Town Percent of Total Removal	13%	23%	25%	39%	100%

Notes:
1. Blue shading denotes entries that are greater than 5% of total (more than 886 kg/yr).
2. Blue shaded entries account for 71% of overall requirement.
3. See Table A-2 and A-3 in Appendix A for derivation of load removal requirements.

5. Implementation Approach and Phasing of PRB Installations

A. General

Criteria and conditions that will drive the phasing of full scale PRB installations include:

- The progress and outcome of the ongoing PRB Demonstration Test;
- Regulatory permitting timelines;
- Selection and access to proposed PRB locations;
- Availability of staffing resources and implementation funds;
- Availability of carbon substrate, subcontractors, and equipment for monitoring well installation and PRB injection; and
- Adaptive management of PRB implementation.

The PRB design process will include four general steps. These steps are outlined below with approximate time frames:

- Initial planning (this Technical Memorandum);
- Preliminary assessments of potential PRB locations and coordination with stakeholders including public workshops (6-months);
- Investigation of short listed locations with hydrogeologic assessments to confirm groundwater flow, actual water quality, and feasibility (9-months); and
- Full-design (1-year).

B. Development of Project Costs

PRB implementation costs have been developed based on estimated linear feet of PRB implementation defined in the ACWMP and cost information from the demonstration test at Eldredge Parkway location. These costs are outlined in Table 2 and include:

- Town Administration and Engineering;
- Engineering - Planning/Consultation;
- Engineering – Design;
- Contractor mobilization and demobilization;
- Monitoring well drilling and installation;
- Monitoring plan and baseline assessment;
- PRB Injections and materials;
- First year monitoring program implementation; and
- Projected annual replacement costs for monitoring wells and PRB rejuvenation injections.

Key Terms

Implementation Costs
Related to costs to Implement or install the proposed PRB. Implementation Costs are generally financed through a loan or bond program. This provides up front funding for implementation, with principal and interest payments spread out over time.

Annual Operations and Maintenance (O&M) Costs
Related to the day-to-day running and upkeep of the system. O&M Costs include items such as labor, utilities, chemicals, etc.

Annual Replacement Costs
Related to the replacement and/or repair of monitoring wells that have been damaged as well as the annualize cost to re-inject EVO.

Annual Monitoring Costs
Related to the annual compliance monitoring determined by the MassDEP. Annual Monitoring Costs include items such as labor and laboratory analysis.

Table 2 - Estimated Costs (July 2018)

Component	Implementation Cost	Annual O&M Cost	Annual Replacement Cost	Annual Monitoring Cost
Site 1 – Rock Harbor Watershed (4,700 LF)				
Design	$518,600			
Implementation, O&M and Monitoring	$4,148,700	$0		$178,600
Replacement			$745,300	
Site 2 – Pleasant Bay Watershed (1,900 LF)				
Design	$210,700			
Implementation, O&M and Monitoring	$1,685,400	$0		$78,300
Replacement			$307,100	
Site 3 – Nauset Harbor Watershed (2,200 LF)				
Design	$244,500			
Implementation, O&M and Monitoring	$1,956,000	$0		$89,100
Replacement			$354,500	

Notes:

1. The design is expected to occur within a one-year period following site selection. The implementation, O&M, and monitoring is expected to begin after the design year, pending appropriation of funding at the prior year's Town Meeting/Special Town Meeting. The annualized replacement costs are anticipated to begin the year following implementation.
2. The estimated linear feet of PRB for the three sites is based on the 2015 Conceptual Approach developed by Stantec for the Town of Orleans. The estimated costs presented are based on these lengths and are expected to vary based on actual length determined during design development.

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 11117 for July 2018.

The probable project costs will need to be updated based on the actual implementation year.

C. Regulatory Permitting

Massachusetts Section 2A of Chapter 259 of the Acts of 2014 required MassDEP to develop a watershed permitting approach to address and optimize nitrogen management measures intended to restore water quality. Planning for Watershed Permits is included in the approved Cape Cod Nitrogen Management Plan (the 208 Plan Update) developed pursuant to Section 208 of the federal Clean Water Act. The 208 Plan Update designates Cape Cod Towns as Waste Treatment Management Agencies (WMAs) responsible for meeting TMDLs on a watershed basis.

In addition to the Watershed Permit, site specific permitting requirements for PRBs will depend on the proposed location. PRBs will be proposed outside of wetland resource areas and sensitive environmental locations where possible. The preferred approach is to install PRBs through Town roads or rights-of-way or potentially on Town-owned properties. Potential permitting requirements and approving authorities are included in Table 3 and described below.

Table 3 - Potential Permit Requirements Depending on Location

Permit	Regulation	Administrating Agency
Massachusetts Environmental Policy Act Permit	Massachusetts Environmental Policy Act Unit	MEPA Unit
Underground Injection Control Registration	Safe Drinking Water Act	MassDEP
Section 106 & Chapter 254 Historic Preservation Act Compliance	Section 106 of the National Historic Preservation Act	Massachusetts Historical Commission
Massachusetts Endangered Species Act Project Review	Massachusetts Endangered Species Act	Massachusetts Division of Fisheries and Wildlife Natural Heritage & Endangered Species Program
Notice of Intent/Order of Conditions	Wetlands Protection Act/ Rivers Protection Act	Town of Orleans Conservation Commission and MassDEP
Road Opening Permits	Massachusetts Chapter 82A Sections 40 through 40D	Town of Orleans Highway Department

D. Massachusetts Environmental Policy Act

PRB projects may be subject to the Massachusetts Environmental Policy Act (MEPA) 301 CMR 11.00. MEPA review is required when one or more review thresholds are met or exceeded and the subject matter of at least one review threshold is within MEPA jurisdiction. In determining whether a Project is subject to MEPA jurisdiction or meets or exceeds any review thresholds it may be necessary to consider all proposed PRBs together to avoid segmentation concerns.

An Environmental Notification Form (ENF) describing the project and potential environmental impacts along with any feasible measures to mitigate potential environmental damage is submitted to the Executive Office of Energy and Environmental Affairs (EEA). EEA solicits comments from the public and state agencies. Following public comment and consultation, the EEA issues a Certificate stating whether an Environmental Impact Report (EIR) is needed and what the scope of the EIR should include, if required. If the EIR is not required, the state permitting agencies can issue the required permits and the project can go forward. Projects located in designated Areas of Critical Environmental Concern require ENF and a Mandatory EIR. Both Pleasant Bay and Rock Harbor are located within state-designated Areas of Critical Environmental Concern.

E. Underground Injection Control Registrations

PRBs will require a MassDEP issued Underground Injection Control (UIC) Registration to comply with UIC Regulations. The UIC Program is responsible for regulating the implementation, operation, permitting, and closure of injection wells that place fluids underground for storage and disposal. The UIC Program requirements were developed by EPA and designed to be adopted by states. The MassDEP UIC Program, defined in 310 CMR 27.00: Underground Injection Control Regulations, details the regulation of injection of fluids within Massachusetts.

To implement a PRB a UIC permit application (MassDEP form BRPWS 06) must be filed with MassDEP under the category “Aquifer Remediation”. The application would include the design parameters and layout of the PRB along with a Water Quality Monitoring Plan. Similar injections of carbon substrates to enhance biodegradation of groundwater chemicals have been commonly implemented in Massachusetts and many of these sites are exempt from the UIC registration process if the injections are conducted for waste site cleanup in accordance with the Massachusetts Contingency Plan (MCP, 310 CMR 40.0000) or similar federal statutes. PRBs will be implemented in compliance with the requirements of the Massachusetts UIC regulations, including all required monitoring. A fee of $585 for each PRB site would be associated with filing the UIC permit. The UIC permit applications should be submitted at least 60 days in advance of the proposed PRB implementation start date. Status reports documenting PRB implementation and monitoring results are subsequently submitted to MassDEP.

F. Historic Preservation Act

At certain locations project review by the Massachusetts Historical Commission (MHC) may be necessary. The MHC administers the Historic Preservation Act. Any projects that require funding, licenses, or permits from any state agency must be reviewed by MHC in compliance with Massachusetts General Laws Chapter 9, sections 26-27C. This law creates the MHC, the office of the State Archaeologist, and the State Register of Historic Places among other historic preservation programs. It provides for MHC review of state projects, State Archaeologist’s Permits, the protection of archaeological sites on public land from unauthorized digging, and the protection of unmarked burials. The regulations that guide MHC review of state funded, licensed or permitted projects are published in 950 CMR 71. These regulations set up a process for the identification of historic properties, assessment of effect, and consultation among interested parties to avoid, minimize, or mitigate any adverse effects. Projects on slopes or uplands adjacent to rivers, lakes, ponds and the ocean are generally considered to be more sensitive to the presence or archaeological artifacts than other locations. Following consultation with MHC, a Project Notification Form (PNF) is submitted to initiate MHC review. The PNF includes a description of the proposed project, existing conditions, and past development of disturbances in the project area.

G. Massachusetts Endangered Species Act Project Review

Projects and activities within rare species habitat must file with the Natural Heritage & Endangered Species Program (NHESP) for review and approval. Habitats in Massachusetts have been mapped as Priority & Estimated Habitats and maps are available on-line. In review, NHESP determines whether the project, as proposed, will impact state-listed species and their habitats and whether or not a project or activity as proposed will result in a "Take" of state-listed species. Projects may have to be revised to avoid a “Take” or be subject to conditions or restrictions to avoid impacts to state-listed species and their habitats and must meet the performance standards for the issuance of a Conservation and Management Permit.

H. Wetlands Protection Act/Rivers Protection Act

If the PRB project is located within 100 feet of a wetland resource area or within 200 feet of a designated riverfront area a Notice of Intent must be submitted for review by the Orleans Conservation Commission. The Commission will issue an Order of Conditions for an approved project.

I. Road Opening Permit

Additional local permits will include Road Opening Permits where PRBs are implemented by injecting through roadways. PRBs systems implementation and monitoring well installation will also likely require agreements for access to private property, mainly for the installation and sampling of monitoring wells.

6. Project Management and Predesign Planning

A. Implementation Team

The successful implementation of PRBs will require coordination between consultant/contractors and the Town of Orleans, including coordination of location access and permit approvals from Town, county, and state authorities. Teams will include:

- Designated Town Officials and Legal staff;
- Consultant staff, with Injection, Drilling, and Laboratory Sub-contractors; and
- Public Participation Coordinator.

It is anticipated that the Town of Orleans will assign a Town Project Manager within the Department of Public Works and Natural Resources and/or an Owner’s Program Manager for implementation coordination. The Consultant will work with the Town Project Manager and a team of specialty subcontractors to plan and implement PRBs. Due to the nature of the project, Town legal staff assistance will be needed to coordinate location access and assistance with permitting. A public participation coordinator will help facilitate public involvement in the project.

B. Pre-implementation Tasks

A detailed project schedule and project progress tracking and reporting system will be developed to identify action items to keep the project on course. The limits of target geographic areas and limits on existing land use for PRB implementation will be developed to inform location selection and monitoring program design and assure that planning is integrated with the ACWMP.

A process for review of specific potential PRBs and location selection, including public participation, will be developed by the Implementation Team to screen candidate PRB sites. The process will include coordination with the US EPA, MassDEP, Cape Cod Commission, and the Pleasant Bay Alliance, a municipal organization formed by the Towns of Orleans, Chatham, Harwich and Brewster to coordinate the resource management plan for the Pleasant Bay Area of Critical Environmental Concern and watershed. It is anticipated that coordination with the Town of Eastham will also be included in the process where PRBs may address shared resources (e.g. Nauset Estuary and Rock Harbor). Following development of a location short list, selected locations will be subject to further investigation to determine specific land use, location of utilities, and an initial groundwater assessment that will be integrated with Water Quality Monitoring Plans described below.

C. Locations Specific Assessment, Baseline Assessment, and Water Quality Monitoring Plans

Potential PRB locations will be reviewed and selected for implementation in accordance with the overall objectives of the Town Comprehensive Wastewater Management Plan, which includes priority areas. Prior to final selection, a location-specific assessment will be necessary to confirm the nature of hydrogeological conditions and groundwater chemistry for PRB design and monitoring plan development and to develop site specific costs on a cost per kilogram of nitrogen removed basis. The cost per kilogram will depend on implementation and monitoring costs, the dimensions of the PRB, and the flux of nitrate through the specific location.

Water Quality Monitoring Plans will be developed for each PRB location. The monitoring program will be developed based on the Conceptual Site Model for PRBs described below and will be developed in a phased approach. The first phase incorporates the initial location assessment, then builds in the baseline assessment needed before PRB implementation at a selected site, and finally the performance monitoring plan that will be used to track PRB efficiency and water quality affects. The assessments will include groundwater profiling and monitoring well sampling and analyses to assess nitrate mass flux and hydrogeologic conditions. Primary objectives of the monitoring plans are to:

- Evaluate potential PRB locations for selection and design based on mass flux of nitrate and feasibility of implementation;
- Assess potential reduction in nitrate concentrations in groundwater compared to baseline samples and/or wells upgradient of the PRB;
- Identify distance traveled by EVO emulsion and DOC;
- Identify extent of generated reducing conditions;
- Assess hydraulic performance;
- Evaluate persistence of EVO emulsion and anaerobic conditions favorable for denitrifying bacteria after PRB injection; and
- Assess changes in groundwater monitoring parameters.
- Estimate the cost per kilogram of nitrate removal.

The monitoring program will be designed to be dynamic and continuously evaluated to adjust the selected monitoring parameters and frequency of monitoring based on data collected and observations. A list of groundwater monitoring parameters is included in Table 4.

Table 4 - Summary of Potential Analyses for Groundwater Evaluation

Parameter	Relevance to PRB Demonstration Test
Nitrate	Primary groundwater compound targeted for treatment.
Nitrite	Intermediate nitrogen species from the aerobic nitrification of ammonia to nitrate.
Ammonia	Reduced inorganic nitrogen species that occurs in proximity of septic system leach fields and landfills.
TKN	Total Kjeldahl Nitrogen (TKN) is the total concentration of organic nitrogen and ammonia.
Total Nitrogen	Analyses provide a summation of all organic and inorganic nitrogen species in groundwater as a result of leach fields and landfill.
CENSUS-DNA (Denitrifying Bacteria)	Analysis quantifies relative abundance of denitrifying bacteria.
Metals (Fe, Mn, As)	Mobility of metals can be impacted by groundwater geochemistry changes, notably pH and ORP.
DOC	Dissolved Organic Carbon (DOC) is the limiting factor in enhancing denitrification-and is increased by injection of EVO. DOC tracks the area of influence of the PRB.
Sulfate	Sulfate will decrease with generation of sufficiently anaerobic conditions favorable for sulfate-reducing bacteria.
pH	Denitrification optimal pH (6.0 and 8.5). Groundwater pH can decrease as a result of fermentation of injected carbon substrates.
ORP	Oxidation-reduction potential (ORP) will decrease with generation of reducing conditions following injection of carbon substrate.
Chloride	Chloride concentrations indicate potentially infiltrating stormwater.
Alkalinity	Denitrification reactions generate alkalinity (3.57 mg of $CaCO_3$ for each mg of nitrate reduced).
Boron	Boron is present in laundry detergents and is an indicator of groundwater flow emanating from leach fields.

D. Adaptive Management

Coordinated implementation of PRBs is necessary to incorporate the Adaptive Management Approach as outlined in the CWMP, where non-structural elements such as PRBs can be implemented in a way that first documents their effectiveness and then allows their full application with predictable results and regulatory support, with the overall goal of reducing the cost of the structural elements. Adaptive Management Plan elements directly related to PRB implementation will require identification of tasks necessary to monitor and refine PRB placement, monitoring programs, and design and implementation methods moving forward. PRB monitoring programs can be integrated with long-term surface water quality monitoring programs for performance evaluation and optimization.

E. Environmental Considerations

Careful selection of PRB installation locations outside sensitive resource areas will be the primary means of minimizing environmental impact. Compliance with environmental permits will be necessary to assure environmental protection and permit requirements will be included in the progress tracking and recording system. Groundwater monitoring results from the Demonstration Test will be used to gauge the potential for secondary impacts to groundwater quality.

F. Conceptual Site Model for PRBs

Site specific PRB implementation assessment will be based on a Conceptual Site Model (CSM) developed for this project for PRBs based on groundwater conditions and the expected fate and transport of large dilute nitrate plumes on Cape Cod. The general (or Cape Cod) CSM is presented with a visualization in Figure 3 and described below.

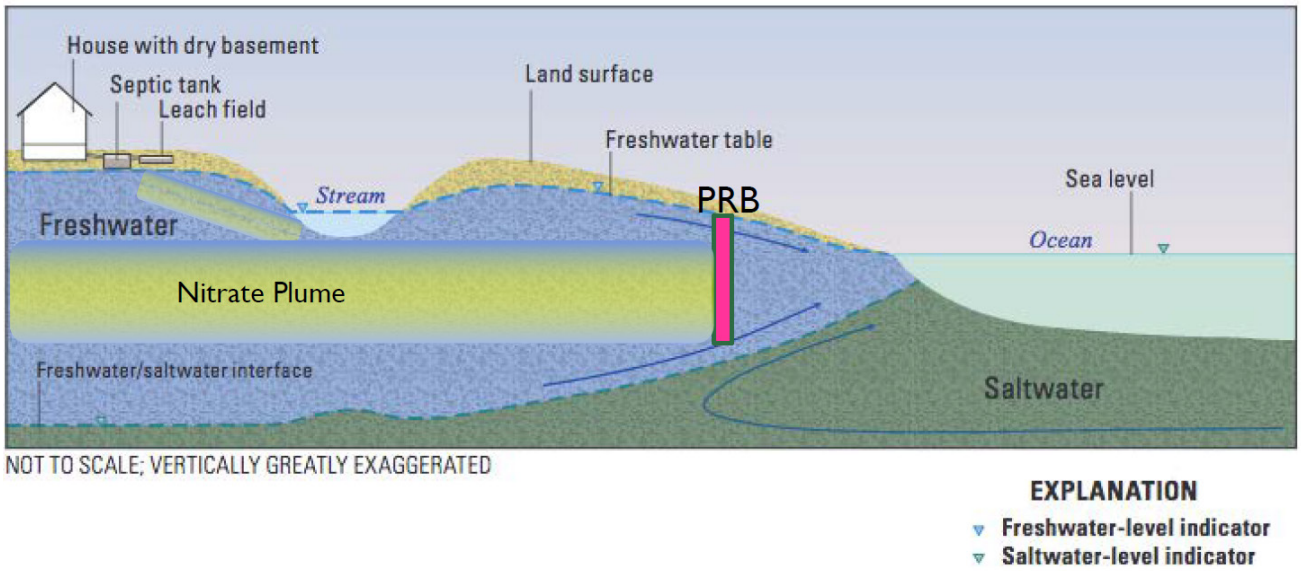
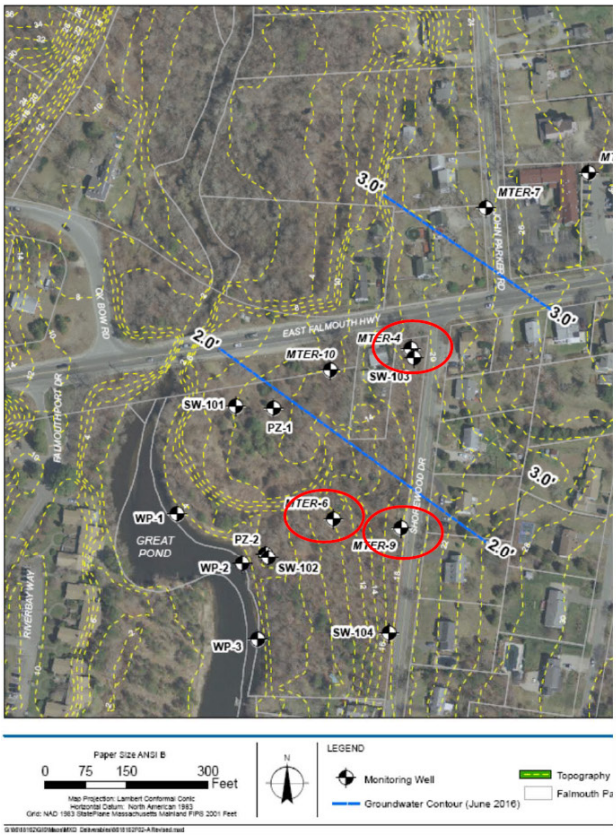


Figure 3 - Visual of Nitrate Plume Treatment PRB
Modified from USGS

Elements of the CSM include the following:

- Groundwater generally flows from the highest water table elevations in the watershed (e.g. approximately 26 feet above sea level in the Nauset Watershed) downgradient toward the receiving surface water body (e.g. Town Cove). In addition to flowing horizontally downgradient, groundwater may flow vertically, recharging deeper portions of the aquifer 100 to 150 feet or more below sea level. Water table elevations vary locally resulting in deviations in local groundwater flow direction.
- The presence of nitrate and nitrate concentrations varies depending on the strength or number of sources upgradient of a location and on the geochemistry of the groundwater. The geochemistry affects fate and transport of nitrogen. Generally septic system nitrogen and nitrogen from fertilizers are released to aerobic groundwater where nitrate is the dominant and most persistent form of nitrogen. Where groundwater travels deep over long distances and into anoxic conditions, natural attenuation may occur. Under these circumstances the profile of nitrate concentrations from shallow to deep in groundwater may indicate that the highest concentrations are generally in shallower groundwater and lower concentrations at depth (see example in Figure 4 below). The profile will in part depend on the distance from sources to the PRB. In recharge areas the plume will move deeper as it travels downgradient.



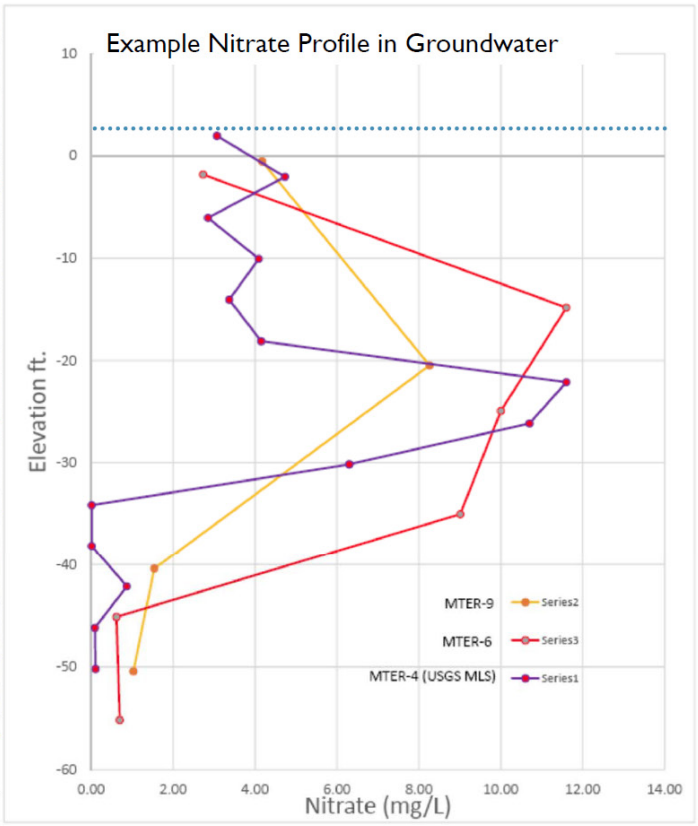


Figure 4 - Example Concentration Profile Nitrate in Groundwater on Cape Cod

- Groundwater flow through freshwater ponds may attenuate nitrogen concentrations.
- Groundwater velocity will vary depending on the local groundwater gradient and hydraulic conductivity of the aquifer material. The aquifer material may contain less permeable clay, silt or fine sand and higher permeability medium sand and gravel. The groundwater velocity may vary from less than 0.1 feet per day to more than 3 feet per day depending on local conditions.
- There may also be layering present in the aquifer material, with layers of more permeable coarser sand and gravel having higher hydraulic conductivity stratified with lower permeability fine sand, silt, or very low hydraulic conductivity clay layers. Mass flux of nitrate would be greater in more permeable layers with faster groundwater flow even if the concentration in lower permeability layers is similar.
- The nitrate treatment PRB will be installed to efficiently intercept the mass flux of nitrate in groundwater upgradient of the surface water to be protected.

The above CSM can be used to develop a site specific CSM to assist in PRB location assessment, PRB design, and development of site specific PRB groundwater monitoring plans. The assessments will include the installation of a set of initial monitoring wells and include groundwater profiling to confirm conditions at depth below the water table. Groundwater profiling will include an assessment of hydraulic conductivity and groundwater chemistry, including redox conditions and one or more nitrogen profiles for the location. Following evaluation of test results and confirmation of location selection, additional monitoring wells will be installed and sampled to establish sufficient information to confirm baseline conditions for comparison and performance assessment once the PRB is in place.

G. Conceptual PRB System Design

PRB conceptual design plans include an overview of installation activities, standard treatment layouts, facilities, and processes to be used to implement the PRB. The PRBs will be installed by injecting a diluted emulsified vegetable oil (EVO) substrate formulation specifically developed to treat nitrate in Cape Cod groundwater. The EVO is injected along a transect line that cuts across the plume of nitrate at the target PRB treatment location. The volume and mixture/type of EVO used to form the PRB will be designed based on the mass flux of nitrate and competing electron acceptors predicted with location specific assessment data. The assessment data may identify high flux zones that can then be targeted as the most cost-effective treatment locations and depths.

Key Terms

Mass flux
A rate measurement specific to a defined area, which is usually a subset of a plume cross section expressed as mass/time/area (e.g., g/d/m2) (ITRC 2010).

Conceptual Site Model (CSM)
Descriptive tool to help understand groundwater conditions and large dilute nitrate plumes on Cape Cod.

Hydraulic Gradient
Groundwater flows down the hydraulic gradient - water table elevations are determined by measuring the depth to water in three or more similar monitoring wells in an area and can then be used to triangulate the hydraulic gradient and horizontal flow direction.

The EVO will be injected with direct push rigs injection rigs (Figure 5) along an injection pathway set perpendicular or close to perpendicular to the groundwater flow direction. The direct push rigs use hydraulics and a vibratory hammer to drive hollow steel rods that serve as piping to the target injection depths. Target injection depths are expected to be up and potentially exceeding 100 feet below ground surface. Injections will be completed with a bottom up approach where the rig will drive direct push rods with typically 4 or 8-foot stainless steel laser cut screens at the bottom of the rods down to the deepest treatment interval. Following the first injection, the screen will be sequentially raised one screen length for subsequent injections until the top of the injection interval is reached.

Direct injection points (without permanent injection well structures) will be located 10 to 15 feet apart depending on the expected radius of influence of injected EVO at each PRB location as determined in the preliminary assessment. The layout and design injection depth will depend on the characteristics of the specific PRB location determined in the location specific assessment.

Design specifications include:

- Depth to ground water;
- PRB length (Linear Feet);
- Target treatment thickness;
- Injection point spacing;
- Number of injection points;
- EVO specification, dilution and additives;
- Injection pressure;



Figure 5 - Direct Injection Rig

- Injection target pore volume;
- Total injection volume (gal); and
- Injection volume per point (gal).

Where possible, PRBs will be implemented along the edge of roadways to minimize implementation related impacts. The objective is to install the PRB in such a way that, following injection, the only indication of the presence of the PRB on the land surface will be the flush mounted surface structure associated with the tops of monitoring wells.

The injection substrate will be delivered to a central staging location or the PRB location in bulk in plastic reusable totes in box trailers, diluted on-site with water to the required strength, and injected. Typically, multiple injection points will be injected simultaneously.

Given the potential length of full scale PRBs, significant advanced planning and coordination with suppliers and field crews will be required. Logistical considerations include:

- A single primary/central staging area will be needed for temporary storage of concentrated EVO in 275-gallon totes. Concentrated volumes required for each specific day can be pulled out of the central staging areas using fork lifts and loaded onto box trucks to move to secondary staging areas adjacent to injection areas. For projects with anticipated multiple secondary staging areas, the use of multiple box trucks can be utilized to minimize any downtime involved with transporting adequate EVO volumes.
- A hydrant water supply and/or water truck will be needed for supplying dilution water near each injection area. Required water supply flow on demand is approximately 40 to 60 gallons per minute.
- Alternatively, diluted EVO batches can be prepared at the central staging area and transported to injection areas on a daily or as-needed basis. Based on weight of water, approximately 6 to 8 totes are near the maximum volume (1,500 to 2,000 gallons) that can be carried in a box truck.
- EVO deliveries to central storage should be sequenced to keep minimum 2 to 3-day buffer to absorb faster/slower injection rates than anticipated. A daily delivery/consumption chart should be prepared and used to coordinate demand and delivery.
- Cumulative injection rates are important to maintain for large volume injections. To sustain high injection rates, 4 to 8 manifolded or dedicated injection lines may need to be operated simultaneously. At high flow rates appropriate staff levels will be needed to coordinate batching, injection, and transport of stock solution, diluted solutions, and/or water.
- Allowable working hours and days will need to be estimated prior to project implementation to effectively deliver EVO and to manage and maintain the injection schedule.
- Traffic flaggers and/or coordination with police for details will be important for maintaining safe working conditions. Police detail may be needed at the central staging area to minimize traffic disturbances with many large trucks arriving at a single location.

The injected EVO provides a long-term source of dissolved organic carbon within and immediately downgradient of the PRB. The dissolved organic carbon is a source of food for naturally occurring groundwater bacteria that will first utilize available oxygen in groundwater for respiration followed by denitrifying bacteria that will utilize nitrate for respiration. This natural process converts available nitrate nitrogen to inert nitrogen gas which is commonly present in groundwater. Once the required biological activity is established the PRB is expected to remove nitrate in groundwater for an extended period of years. The nitrogen load reduction that will be achieved can be predicted with the mass flux of nitrate identified in the assessment.

The process of establishing the PRB biological community in the treatment zones is expected to take several months based on the lag time for increases in naturally occurring biomass. The amount of time required to confirm the increase in biological activity (or biomass) will depend in part on the distance to downgradient monitoring wells along with groundwater velocity and travel time.

eventually, the efficiency of nitrate treatment will begin to decline once the carbon source starts to be depleted. Depletion is expected to occur in high mass flux areas first and will be indicated by decreasing dissolved organic carbon levels and increasing nitrate concentration at downgradient monitoring wells. Once the treatment efficiency decreases to a defined tolerance limit, rejuvenation of the PRB by subsequent injection will be required. The ongoing Demonstration Test is being monitored to assess longevity to provide specific guidance for PRBs in Orleans; expected operational time frames range from 5 to 10 years or more.

H. Post Implementation Tasks

Following implementation of individual PRBs an As-built Completion Report will be prepared documenting implementation, final inspections, and updated Water Quality Monitoring Plans. The report can then be used in conjunction with the Adaptive Management Approach, post installation monitoring, and reporting to track progress toward water quality goals.

7. References

Interstate Technology & Regulatory Council (ITRC) (2010)- Use and Measurement of Mass Flux and Mass Discharge

Interstate Technology & Regulatory Council (ITRC) (2011)- Permeable Reactive Barrier: Technology Update (PRB-5)

MassDEP (May 2007) “Pleasant Bay System, Total Maximum Daily Loads for Total Nitrogen” (Report #96- TMDL-12, Control #244.0)

Howes B., S. W. Kelley, J. S. Ramsey, R. Samimy, D. Schlezinger, E. Eichner (2006). Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Pleasant Bay, Chatham, Massachusetts. Massachusetts Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA

Howes B., S. W. Kelley, J. S. Ramsey, R. Samimy, D. Schlezinger, E. Eichner (2007). Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Rock Harbor Embayment System Towns of Orleans and Eastham, Massachusetts

Howes B., S. W. Kelley, J. S. Ramsey, R. Samimy, D. Schlezinger, E. Eichner (2012). Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Nauset Harbor Embayment System Towns of Orleans and Eastham, Massachusetts

Pleasant Bay Alliance (2017) Pleasant Bay Composite Nitrogen Management Analysis

Appendix B: Full-Scale PRB Selection Matrix

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Table 1
Orleans PRB Selection Matrix

Pleasant Bay Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	Length (ft)	Roads	Saturated Depth (ft)	Depth Range to GW (ft)	Estimated Parcels	Estimated Sewer Load reduced (kg/yr) at 80% PRB Efficiency	Embayment Non-Traditional Technology Goal (kg/yr)	Estimated kg/LF/yr	Pleasant Bay Watershed PRB kg/yr Efficincy Rank	PRB Installation Cost Estimate	30-year LCCA for PRB (Present Worth)	Evaluation Notes
Meeting House Pond	None						**0**	**0**	**40**					
Lonnies Pond/Kescayo Gansett River							**41**	**178**	**284**					
Lonnies Pond/Kescayo Gansett River	Monument	25, 26 Lonnies Pond/Kescayo Gansett River	1,675	Monument	30	25 to 50	41	178		0.11	**8**	$2,060,250	$4,889,900	Upper Reach Priority embayment
Aerys Pond	None						**0**	**0**	**113**					
Upper River							**26**	**113**	**202**					
Upper River	Keziahs	41 Upper River	1,250	Keziahs	30	15 to 40	26	113		0.09	**9**	$1,537,500	$3,775,700	Upper Reach Priority embayment
Lower River							**35**	**152**	**517**					
Lower River	Mayflower	28 Lower River	1,700	Pershing, Kenneth	30	10 to 30	35	152		0.09	**11**	$2,091,000	$4,969,200	
Namequoit River							**56**	**244**	**348**					
Namequoit River	Namequoit	30 Namequoit River	1,000	Namequoit Road	30	10 to 40	27	117		0.12	**6**	$1,230,000	$7,577,200	Upper Reach Priority embayment
Namequoit River	Ridge	30 Namequoit River	460	Ridgewood Rd	30	10 to 30	29	126		0.27	**1**	$565,800	d with Namequoit PRB	Upper Reach Priority embayment
Pah Wah Pond							**35**	**152**	**413**					
Pah Wah Pond	Lockwood	32 Pah Wah Pond	1,230	Lockwood	30	5 to 15	35	152		0.12	**5**	$1,512,900	d with Namequoit PRB	Upper Reach Priority embayment
Quanset and Pleasant Bay Main Basin							**122**	**531**	**1485**					
Quanset and Pleasant Bay Main Basin	Quonset 1,2,3	33, 37 Pleasant Bay and Quanset Pond	1,745	Towhee, Lake Dr, Oyster	30	10 to 40	43	187		0.11	**7**	$2,146,350	$5,071,900	Upper Reach Priority embayment
Quanset and Pleasant Bay Main Basin	Grannys	33, 37 Pleasant Bay and Quanset Pond	650	Grannys Ln	30	15 to 20	24	104		0.16	**4**	$799,500	$2,174,200	Upper Reach Priority embayment
Quanset and Pleasant Bay Main Basin	Winslow	33, 37 Pleasant Bay and Quanset Pond	1,150	Winslow Dr and Way	30	5 to 40	14	61		0.05	**14**	$1,414,500	$3,496,900	Upper Reach Priority embayment
Quanset and Pleasant Bay Main Basin	Richwood	33, 37 Pleasant Bay and Quanset Pond	890	Richwood Farm	30	10 to 15	41	178		0.20	**2**	$1,094,700	$2,805,100	Upper Reach Priority embayment
Pochet							**171**	**744**	**1,564**					
Pochet	Duck Hole	35 Pochet Neck Stream	4,100	High View, Old Duck Hole, Lovell	30	5 to 35	68	296		0.07	**12**	$5,043,000	$11,335,800	Upper Reach Priority embayment
Pochet	Gosnold	34, 35 Pochet and Pochet Neck Stream	2,081	Gosnold,	30	10 to 30	29	126		0.06	**13**	$2,559,630	$5,966,700	Upper Reach Priority embayment
Pochet	Briar Spring	34 Pochet	2,906	Briar Spring	30	10 to 35	59	257		0.09	**10**	$3,574,380	$8,168,400	Upper Reach Priority embayment
Pochet	Blossom	35 Pochet	400	Blossom , Sparrowhawk	30	30 to 40	15	65		0.16	**3**	$492,000	$1,513,400	Upper Reach Priority embayment
Pleasant Bay Estuary (Orleans)			**21,237**				**486**	**2,115**	**4,966**			**$26,121,510**	**$61,744,400**	
	Average Efficiency kg/LF/yr									**0.10**				

Nauset Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	Length (ft)	Roads	Saturated Depth (ft)	Depth Range to GW (ft)	Estimated Parcels	Estimated Sewer Load reduced (kg/yr) at 80% PRB Efficiency	Embayment Non-Traditional Technology Goal (kg/yr)	Estimated kg/LF/yr	Pleasant Bay Watershed PRB kg/yr Efficincy Rank	PRB Installation Cost Estimate	30-year LCCA for PRB (Present Worth)	Evaluation Notes
Town Cove							**171**	**744**	**566**					
Town Cove	Tonset	5 Town Cove	7,300	Gibson, Tonset	30	10 to 30	93	405		0.06	**3**	$8,979,000	$22,059,000	Upper Reach Priority embayment
Town Cove	Main	5 Town Cove	850	Main	40	5 to 10	78	339		0.40	**2**	$1,045,500	luded with Tonset PRB	Upper Reach Priority embayment
Mill Pond							**28**	**122**						
Mill Pond	Norseman	8 Mill Pond	580	Norsemans Road, Mill Pond Rd	40	10 to 35	28	122		0.21	**1**	$713,400	$1,999,700	Upper Reach Priority embayment
Nauset Estuary (Orleans)			**8,730**				**199**	**866**				**$10,737,900**	**$24,058,700**	
	Average Efficiency kg/LF/yr									**0.22**				

Rock Harbor Estuary (Orleans)

Embayment	PRB Name	MEP Watershed ID	Length (ft)	Roads	Saturated Depth (ft)	Depth Range to GW (ft)	Estimated Parcels	Estimated Sewer Load reduced (kg/yr) at 80% PRB Efficiency	Embayment Non-Traditional Technology Goal (kg/yr)	Estimated kg/LF/yr	Pleasant Bay Watershed PRB kg/yr Efficincy Rank	PRB Installation Cost Estimate	30-year LCCA for PRB (Present Worth)	Evaluation Notes
Rock Harbor Main	**Rock Harbor**						**70**	**305**	**634**					
Rock Harbor	Rock Harbor	3 Rock Harbor Main	3,940	Rock Harbor	50	5 to 15	70	305		0.08	1	$103,425	$10,896,700	Upper Reach Priority embayment
Rock Harbor Estuary (Orleans)	**Rock Harbor**		**3,940**				**70**	**305**	**634**	**0.08**		**$4,846,200**	**$10,896,700**	

PRB Townwide Potential Total			**33,907**				**755**	**3,286**				**$41,705,610**	**$96,699,800**	

Appendix C: Boring Logs

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Project Number:	60476644	*Project Manager:* Tom Parece	AECOM 9 Jonathan Bourne Drive Pocasset, Massachusetts (508)-833-6950
Client:	Town of Orleans, MA	*Field Tech(s):* CH/MO/DD	
Site Location:	Route 6A Orleans, MA		

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:* Sonic Drill	***Boring Number:***	**BR-1**	
Date	Monday, August 30, 2021		*Sheet:*		of
			Surface Elevation (ft-asl):	TBD	
Drill Contractor:	Redox Tech, LLC	*Equipment:* Geoprobe 8150LS	Boring Depth (ft):	100	
Date	Friday, September 17, 2021		*Inside Diameter (inches):*	2	
			Screen Depth:	N/A	
			Screen Length:	N/A	

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear 0 ft		dry	0 - 4' : Very dense tan fine to coarse sand, little fine to coarse gravel (fill)				1
2	to 6 ft		dry	4' - 6' : Native tan fine to coarse sand, trace fine gravel, loose				2
3								3
4								4
5								5
6	5 ft to							6
7	10 ft		dry	7' - 33' : Mottled tan/light brown (slightly oxidized) medium to coarse sand, little fine sand, trace fine gravel wet @ 27 ft				7
8								8
9								9
10								10
11	10 ft to							11
12	15 ft							12
13								13
14								14
15								15
16	15 ft to							16
17	20 ft							17
18								18
19								19
20								20
21	20 ft to							21
22	25 ft							22
23								23
24								24
25								25
26	25 ft to							26
27	30 ft							27
28								28
29								29
30								30
31	30 ft to							31
32	35 ft							32
33			dry	33' - 34' : Light brown fine to medium sand, trace coarse sand				33
34			dry	34' - 38' : Mottled tan/light brown (slightly oxidized) medium to coarse sand, little fine sand, trace gravel				34
35								35

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM
9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**BR-1**
Date	Monday, August 30, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Friday, September 17, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft							36
37								37
38			dry	38' - 39' : Tan medium to coarse sand, trace fine gravel				38
39			dry	39' - 40.5' : Brown fine to medium sand, little coarse sand, trace silt,				39
40			dry	40.5' - 64' : Tan medium to coarse sand, trace fine gravel		▼		40
41	40 ft to 45 ft							41
42								42
43								43
44								44
45								45
46	45 ft to 50 ft							46
47								47
48								48
49								49
50								50
51	50 ft to 55 ft							51
52								52
53								53
54								54
55								55
56	55 ft to 60 ft							56
57								57
58								58
59								59
60								60
61	60 ft to 65 ft							61
62								62
63								63
64			dry dry	64' - 64.5' : Tan fine to medium sand, little coarse sand, very small brown silt 64.5' - 66.5' : Tan medium to coarse sand, trace fine gravel				64
65								65
66	65 ft to 70 ft		dry	66.5' - 67' : Brown mottled silt				66
67			dry	67' - 69' : Oxidized brown/orange medium to coarse sand, some fine sand, trace fine gravel				67
68								68
69			dry	69' - 71' : Tan medium to coarse sand, trace fine gravel				69
70								70

Project Number:	60476644	*Project Manager:* Tom Parece	AECOM
Client:	Town of Orleans, MA	*Field Tech(s):* CH/MO/DD	9 Jonathan Bourne Drive Pocasset, Massachusetts (508)-833-6950
Site Location:	Route 6A Orleans, MA		

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:* Sonic Drill	***Boring Number:***	**BR-1**	
Date	Monday, August 30, 2021		*Sheet:*		of
			Surface Elevation (ft-asl):	TBD	
Drill Contractor:	Redox Tech, LLC	*Equipment:* Geoprobe 8150LS	Boring Depth (ft):	100	
Date	Friday, September 17, 2021		*Inside Diameter (inches):*	2	
			Screen Depth:	N/A	
			Screen Length:	N/A	

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft		dry dry	71' - 71.25' : Brown silt 71.25' - 76' : Brown medium to coarse sand, some fine gravel, little fine silt, trace silt				71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft		dry	76' - 82' : Starts with small brown silt, slightly oxidized				76
77								77
78								78
79								79
80								80
81	80 ft to 85 ft							81
82			dry	82' - 86' : Light brown/light orange coarse sand, some medium sand and fine gravel, trace fine sand				82
83								83
84								84
85								85
86	85 ft to 90 ft		dry dry	86' - 86.5' : Tight fine to medium sand, little coarse sand 86.5' - 91' : Light brown/light orange coarse sand, some medium sand and fine gravel, trace fine sand				86
87								87
88								88
89								89
90								90
91	90 ft to 95 ft		dry	91' - 93' : Brown fine to medium sand, some coarse sand, trace fine gravel				91
92								92
93			dry	93' - 95' : Light brown/light orange coarse sand, some medium sand and fine gravel, trace fine sand				93
94								94
95			dry	95' - 96' : Gray mottled silty fine sand, little medium sand, heavily oxidized at 97.5 ft				95
96	95 ft to 100 ft							96
97			dry	97.5' - 100' : Gray mottled silty fine sand, little medium sand				97
98								98
99								99
100				---------- End of Boring at 100' ----------				100

Project Number:	60476644	*Project Manager:* Tom Parece	AECOM 9 Jonathan Bourne Drive Pocasset, Massachusetts (508)-833-6950
Client:	Town of Orleans, MA	*Field Tech(s):* CH/MO/DD	
Site Location:	Route 6A Orleans, MA		

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:* Sonic Drill	***Boring Number:***	**BR-2**	
Date	Thursday, September 16, 2021		*Sheet:*		of
			Surface Elevation (ft-asl):	TBD	
Drill Contractor:	Redox Tech, LLC	*Equipment:* Geoprobe 8150LS	Boring Depth (ft):	100	
Date	Thursday, September 16, 2021		*Inside Diameter (inches):*	2	
			Screen Depth:	N/A	
			Screen Length:	N/A	

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear	3.0	dry	0' - 1' : Topsoil with roots and gravel				1
	0 ft		dry	1' - 2' : Brown /dark brown fine to coarse sand, some silt, little fine gravel				
2	to		dry	2' - 3' : tan/light brown medium sand, some fine coarse sand, trace fine gravel				2
	6 ft							
3		12.0	dry	3' - 15' : Tan/light brown fine to medium sand, little coarse sand, fine gravel, trace silt				3
4								4
5								5
6	5 ft							6
	to							
7	10 ft							7
8								8
9								9
10								10
11	10 ft							11
	to							
12	15 ft							12
13								13
14								14
15		5.0	moist	15' - 20' : Tan fine to coarse sand, trace fine gravel, moist @ 20 ft				15
16	15 ft							16
	to							
17	20 ft							17
18								18
19								19
20			wet	20' - 26.5' : Tan/light brown fine to coarse sand, trace fine gravel, wet @ 21 ft				20
21	20 ft					▼		21
	to							
22	25 ft							22
23								23
24								24
25								25
26	25 ft		dry	26.5' - 38' : Light brown- orange fine to coarse sand, trace fine sand and fine gravel				26
	to							
27	30 ft							27
28								28
29								29
30								30
31	30 ft							31
	to							
32	35 ft							32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**BR-2**
Date	Thursday, September 16, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Thursday, September 16, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft							36
37								37
38			dry	38' - 52' : Light brown-orange fine to coarse sand, little fine gravel, moderate oxidation				38
39								39
40								40
41	40 ft to 45 ft							41
42								42
43								43
44								44
45								45
46	45 ft to 50 ft							46
47								47
48								48
49								49
50								50
51	50 ft to 55 ft							51
52			dry	52' - 52.5' : Tan-brown fine sand, mottled silt				52
			dry	52.5' - 56' : Tan/brown medium to coarse sand, some fine sand, mottled and oxidized				
53								53
54								54
55								55
56	55 ft to 60 ft		dry	56' - 58' : Mottled brown fine sand and silt, little medium sand, trace clay, non-plastic				56
57								57
58			dry	58' - 62' : Brown-slightly red fine to medium sand, little silt, trace coarse sand, slightly oxidized				58
59								59
60								60
61	60 ft to 65 ft							61
62			dry	62' - 63' : Brown-slightly red fine to medium sand, little silt, trace coarse sand, trace cly, non-plastic				62
63			dry	63' - 77' : Tan/light brown fine to coarse sand, trace fine gravel				63
64								64
65								65
66	65 ft to 70 ft							66
67								67
68								68
69								69
70								70

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM
9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**BR-2**
Date	Thursday, September 16, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Thursday, September 16, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft							71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft							76
77			dry	77' - 86.5' : Brown fine to coarse sand, little fine gravel				77
78								78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83								83
84								84
85								85
86	85 ft to 90 ft		dry	86.5' - 87' : 1" - 2" thik gray silt layer in this interval				86
87			dry	87' - 91' : Brown/gray medium to coarse sand and fine gravel, little fine sand, trace silt				87
88								88
89								89
90								90
91	90 ft to 95 ft		dry	91' - 92' : Red-brown (oxidized) fine to medium sand, some coarse sand, trace silt and fine gravel				91
92			dry	92' - 93' : Gray/tan silt and fine sand, some medium sand, trace coarse sand, weak (non-plastic)				92
93			dry	93' - 96' : Brown medium to coarse sand, some fine gravel and fine sand				93
94								94
95								95
96	95 ft to 100 ft		dry	96' - 100' : Gray silt and fine sand				96
97								97
98								98
99								99
100				---------- End of Boring at 100' ----------				100

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**BR-3**
Date	Wednesday, September 15, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Thursday, October 07, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear 0 ft to 6 ft		dry	0' 8' : Topsoil and grass, then light brown fine to medium sand, some coarse sand, little fine gravel				1
2								2
3								3
4								4
5								5
6	5 ft to 10 ft							6
7								7
8		4.0	dry	8' - 18' : tan medium sand				8
9								9
10								10
11	10 ft to 15 ft							11
12								12
13								13
14								14
15								15
16	15 ft to 20 ft							16
17								17
18		1.0	dry	18' - 28' : tan to yellowish brown medium sand				18
19								19
20								20
21	20 ft to 25 ft							21
22								22
23								23
24								24
25								25
26	25 ft to 30 ft							26
27								27
28			dry	28' - 38' : Brown medium sand				28
29								29
30								30
31	30 ft to 35 ft							31
32								32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM
9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**BR-3**
Date	Wednesday, September 15, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Thursday, October 07, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft		dry	38' - 48' : Brown-Tan medium sand				36
37								37
38								38
39								39
40								40
41	40 ft to 45 ft							41
42						▼		42
43								43
44								44
45								45
46	45 ft to 50 ft		dry	48' - 58' : Brown-yellowish brown medium sand				46
47								47
48								48
49								49
50								50
51	50 ft to 55 ft							51
52								52
53								53
54								54
55								55
56	55 ft to 60 ft		dry	58' - 68' : Brown medium sand				56
57								57
58								58
59								59
60								60
61	60 ft to 65 ft							61
62								62
63								63
64								64
65								65
66	65 ft to 70 ft		dry	68' - 78' : Brown fine to medium sand				66
67								67
68								68
69								69
70								70

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**BR-3**
Date	Wednesday, September 15, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Thursday, October 07, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft							71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft							76
77								77
78			dry	78' - 88' : medium silt and sand with clay layer				78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83								83
84								84
85								85
86	85 ft to 90 ft							86
87								87
88			dry	88' - 94' : Medium red-brown sand with layers of clay and silt				88
89								89
90								90
91	90 ft to 95 ft							91
92								92
93								93
94			dry	94' - 100' : Yellowish brown medium sand				94
95								95
96	95 ft to 100 ft							96
97								97
98								98
99								99
100				---------- End of Boring at 100' ----------				100

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Vac-Truck	***Boring Number:***	**BR-4**
Date	Wednesday, October 06, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Wednesday, October 06, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear 0 ft to 6 ft		dry	0' - 8' : Brown fine sand				1
2								2
3								3
4								4
5								5
6	5 ft to 10 ft							6
7								7
8			dry	8' - 12' : Dense gray silt and clay				8
9								9
10								10
11	10 ft to 15 ft		dry	12' - 18' : Medium to coarse brown and red sand				11
12								12
13								13
14								14
15								15
16	15 ft to 20 ft							16
17								17
18			dry	18' - 28' : Medium to coarse brown sand with packed clay, gray				18
19								19
20								20
21	20 ft to 25 ft							21
22								22
23								23
24								24
25								25
26	25 ft to 30 ft							26
27								27
28			dry	28' - 38' : Medium to coarse sand, dense silt, coarse sand				28
29								29
30								30
31	30 ft to 35 ft							31
32								32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM

9 Jonathan Bourne Drive
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Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Vac-Truck
Date	Wednesday, October 06, 2021		
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS
Date	Wednesday, October 06, 2021		

Boring Number:	**BR-4**
Sheet:	of
Surface Elevation (ft-asl):	TBD
Boring Depth (ft):	100
Inside Diameter (inches):	2
Screen Depth:	N/A
Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft		dry	38' - 42' : Fine to medium sand with gravel , brown to tan				36
37								37
38								38
39								39
40								40
41	40 ft to 45 ft		dry	42' - 48' : Tan fine sand with dense silt				41
42								42
43								43
44								44
45								45
46	45 ft to 50 ft		dry	48' - 58' : Brown medium to coarse sand				46
47								47
48								48
49								49
50								50
51	50 ft to 55 ft					▼		51
52								52
53								53
54								54
55								55
56	55 ft to 60 ft		dry	58' - 68' : Brown medium sand				56
57								57
58								58
59								59
60								60
61	60 ft to 65 ft							61
62								62
63								63
64								64
65								65
66	65 ft to 70 ft		dry	68' - 77' : Medium brown and red sand				66
67								67
68								68
69								69
70								70

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM

9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Vac-Truck
Date	Wednesday, October 06, 2021		
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS
Date	Wednesday, October 06, 2021		

Boring Number:	**BR-4**
Sheet:	of
Surface Elevation (ft-asl):	TBD
Boring Depth (ft):	100
Inside Diameter (inches):	2
Screen Depth:	N/A
Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft							71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft							76
77			dry	77' 78' : Gray-brown dense silt				77
78			dry	78' - 85' : Gray-brown dense silt				78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83								83
84								84
85			dry	85' - 88' : Coarse sand and gravel				85
86	85 ft to 90 ft							86
87								87
88			dry	88' - 100' : Fine to medium sand				88
89								89
90								90
91	90 ft to 95 ft							91
92								92
93								93
94								94
95								95
96	95 ft to 100 ft							96
97								97
98								98
99								99
100				---------- End of Boring at 100' ----------				100

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM

9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill
Date	Tuesday, August 31, 2021		
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS
Date	Saturday, October 02, 2021		

Boring Number:	**BR-5**
Sheet:	of
Surface Elevation (ft-asl):	TBD
Boring Depth (ft):	100
Inside Diameter (inches):	2
Screen Depth:	N/A
Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear 0 ft to 6 ft		dry	0' - 5' : Very dense, hard-packed fine to medium silt, little medium sand, trace fine to coarse gravel				1
2			dry	5' - 6' : Brown-Light Orange dense fine to medium sand, some coarse sand, little fine gravel				2
3								3
4								4
5								5
6	5 ft to 10 ft		wet	6' - 10' : Brown/gray fine sand and silt, trace clay, medium sand, wet at 6 ft				6
7								7
8								8
9								9
10			dry dry	10' - 10.5' : Light brown fine to medium sand, little silt 10.5' - 15' : Gray clayey fine sand and silt, plastic, weak				10
11	10 ft to 15 ft							11
12								12
13								13
14								14
15			dry	15' - 25' : Tan/light brown fine to coarse sand, little fine gravel, water at approximately 19 ft				15
16	15 ft to 20 ft							16
17								17
18								18
19								19
20								20
21	20 ft to 25 ft							21
22						▼		22
23								23
24								24
25			dry	25' - 27' : Gray clayey fine sand and silt, plastic, weak				25
26	25 ft to 30 ft							26
27			dry	27' - 31' : Tan/light brown fine to coarse sand, trace coarse gravel				27
28								28
29								29
30								30
31	30 ft to 35 ft		dry	31' - 36' : Gray clayey fine sand and silt, plastic, weak heavily oxidized for approximately 1 to 3 inches intervals				31
32								32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**BR-5**
Date	Tuesday, August 31, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Saturday, October 02, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft		dry	36' - 46' : Tan/light brown fine to coarse sand, little fine gravel, very loose				36
37								37
38								38
39								39
40								40
41	40 ft to 45 ft							41
42								42
43								43
44								44
45								45
46	45 ft to 50 ft		dry	46' - 48' : Brown/ light gray fine sand and silt, mottled by oxidation (moderate)				46
47								47
48			dry	48' - 67' : Tan/light brown fine to coarse sand, trace coarse gravel, thin gray silt layer				48
49								49
50								50
51	50 ft to 55 ft							51
52								52
53								53
54								54
55								55
56	55 ft to 60 ft							56
57								57
58								58
59								59
60								60
61	60 ft to 65 ft							61
62								62
63								63
64								64
65								65
66	65 ft to 70 ft							66
67			dry	67' - 69' : Tan/light brown fine to coarse sand, trace coarse gravel				67
68								68
69			dry	69' - 69.5' : Tan/light brown fine to coarse sand, soft clayey gray silt				69
70			dry	70' - 77' : Tan/light brown fine to coarse sand, fine gravel				70

Project Number:	60476644	*Project Manager:* Tom Parece	AECOM 9 Jonathan Bourne Drive Pocasset, Massachusetts (508)-833-6950
Client:	Town of Orleans, MA	*Field Tech(s):* CH/MO/DD	
Site Location:	Route 6A Orleans, MA		

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:* Sonic Drill	***Boring Number:***	**BR-5**	
Date	Tuesday, August 31, 2021		*Sheet:*		of
			Surface Elevation (ft-asl):	TBD	
Drill Contractor:	Redox Tech, LLC	*Equipment:* Geoprobe 8150LS	Boring Depth (ft):	100	
Date	Saturday, October 02, 2021		*Inside Diameter (inches):*	2	
			Screen Depth:	N/A	
			Screen Length:	N/A	

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft							71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft							76
77			dry	77' - 91' : Tan/light brown fine to coarse sand, trace coarse gravel				77
78								78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83								83
84								84
85								85
86	85 ft to 90 ft							86
87								87
88								88
89								89
90								90
91	90 ft to 95 ft		dry	91' - 99' : Gray fine sand, little silt, trace medium to coarse sand, medium dense to dense				91
92								92
93								93
94								94
95								95
96	95 ft to 100 ft							96
97								97
98								98
99				99' 100' : Gray fine to coarse sand				99
100				---------- End of Boring at 100' ----------				100

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**BR-6**
Date	Tuesday, August 31, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Saturday, September 18, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear 0 ft		dry	0 - 2.5' : Hard packed, dense tan fine to medium sand, trace coarse sand and fine gravel				1
2	to 6 ft		dry	2.5' - 6' : Very dense, hard-packed fine to medium silt, little medium sand, trace fine to coarse gravel				2
3								3
4								4
5								5
6	5 ft to		dry	6' - 23' : Brown/Gray silt, some fine sand, mottled with slight oxidationn, trace fine sand				6
7	10 ft							7
8								8
9								9
10								10
11	10 ft to							11
12	15 ft							12
13								13
14								14
15								15
16	15 ft to							16
17	20 ft							17
18								18
19								19
20								20
21	20 ft to							21
22	25 ft							22
23			dry	23' - 44' : Brown/tan fine to coarse sand, little fine gravel, wet at 40 ft				23
24								24
25								25
26	25 ft to							26
27	30 ft							27
28								28
29								29
30								30
31	30 ft to							31
32	35 ft							32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM
9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**BR-6**
Date	Tuesday, August 31, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Saturday, September 18, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft							36
37								37
38								38
39								39
40								40
41	40 ft to 45 ft					▼		41
42								42
43								43
44			dry	44' - 60' : Tan medium to coarse sand, little fine sand, trace fine to coarse gravel				44
45								45
46	45 ft to 50 ft							46
47								47
48								48
49								49
50								50
51	50 ft to 55 ft							51
52								52
53								53
54								54
55								55
56	55 ft to 60 ft							56
57								57
58								58
59								59
60			dry	60' - 70.5' : Tan/light brown medium to coarse sand, some fine sand, trace fine gravel				60
61	60 ft to 65 ft							61
62								62
63								63
64								64
65								65
66	65 ft to 70 ft							66
67								67
68								68
69								69
70			dry	70.5' - 72' : Brown fine sand and silt, trace medium sand				70

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**BR-6**
Date	Tuesday, August 31, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Saturday, September 18, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft		dry	72' - 79' : Tan medium to coarse sand, little fine sand, trace fine to coarse gravel, mostly brown				71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft							76
77								77
78								78
79			dry	79' - 81.5' : Brown/tan medium sand, some fine to coarse sand, trace fine gravel				79
80								80
81	80 ft to 85 ft		dry	81.5' - 85' : Brown/light orange slightly oxidized medium to coarse sand, little fine sand and fine gravel, heavily-oxidized la				81
82								82
83								83
84								84
85								85
86	85 ft to 90 ft		ry	85' - 89' : Brown fine to medium sand, little coarse sand, trace gravel				86
87								87
88								88
89			dry	89' - 95' : Brown/light orange slightly oxidized medium to coarse sand, little fine sand and fine				89
90								90
91	90 ft to 95 ft							91
92								92
93								93
94								94
95			dry	95' - 100' : Brown/orange medium to coarse sand, some fine sand and gravel				95
96	95 ft to 100 ft							96
97								97
98								98
99								99
100				---------- End of Boring at 100' ----------				100

Project Number:	60476644	*Project Manager:* Tom Parece	AECOM 9 Jonathan Bourne Drive Pocasset, Massachusetts (508)-833-6950
Client:	Town of Orleans, MA	*Field Tech(s):* CH/MO/DD	
Site Location:	Route 6A Orleans, MA		

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:* Sonic Drill	***Boring Number:***	**DU-1**	
Date	Monday, September 20, 2021		*Sheet:*		of
			Surface Elevation (ft-asl):	TBD	
Drill Contractor:	Redox Tech, LLC	*Equipment:* Geoprobe 8150LS	Boring Depth (ft):	100	
Date	Monday, September 20, 2021		*Inside Diameter (inches):*	2	
			Screen Depth:	N/A	
			Screen Length:	N/A	

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear 0 ft to 6 ft		dry	0' - 7' : Brown -tan fine to coarse sand, little fine gravel and root fibers				1
2								2
3								3
4								4
5								5
6	5 ft to 10 ft		dry	7' - 24' : Brown-orange (slightly to moderately oxidized) fine to coarse sand, little fine gravel				6
7								7
8								8
9								9
10								10
11	10 ft to 15 ft							11
12								12
13								13
14								14
15								15
16	15 ft to 20 ft							16
17								17
18								18
19								19
20								20
21	20 ft to 25 ft							21
22						▼		22
23								23
24			wet	24' - 40' : Tan medium to coarse sand, some fine sand, trace fine gravel, wet at 25 ft				24
25								25
26	25 ft to 30 ft							26
27								27
28								28
29								29
30								30
31	30 ft to 35 ft							31
32								32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**DU-1**
Date	Monday, September 20, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Monday, September 20, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft							36
37								37
38								38
39								39
40			dry	40' -42' : Brown/tan fine to medium sand, little coarse sand, trace fine gravel				40
41	40 ft to 45 ft							41
42			dry	42' - 45' : Brown-tan medium to coarse sand, some fine sand, trace fine gravel				42
43								43
44								44
45			dry	45' - 64' : brown-tan fine to medium sand, little coarse sand, trace fine gravel Brown mottled silt at 53' - 53.3'/ Brown mottled fine sand and silt at 57'- 58'				45
46	45 ft to 50 ft							46
47								47
48								48
49								49
50								50
51	50 ft to 55 ft							51
52								52
53								53
54								54
55								55
56	55 ft to 60 ft							56
57								57
58								58
59								59
60								60
61	60 ft to 65 ft							61
62								62
63								63
64			dry	64' - 67' : Light brown-tan mottled fine sand, some silt, little medium sand				64
65								65
66	65 ft to 70 ft							66
67			dry	67' - 72' : Tan medium to coarse sand, some fine sand, trace fine gravel				67
68								68
69								69
70								70

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM
9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**DU-1**
Date	Monday, September 20, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Monday, September 20, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft		dry	71' - 92' : Brown/tan fine to medium sand, little coarse sand, trace fine gravel, thin (<1.5") brown silt at 92 ft				71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft							76
77								77
78								78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83								83
84								84
85								85
86	85 ft to 90 ft							86
87								87
88								88
89								89
90								90
91	90 ft to 95 ft							91
92			dry	92' - 94' : Tan medium to coarse sand, some fine sand, trace fine gravel				92
93								93
94			dry	94' - 95.5' : Light brown-tan mottled fine sand, some silt, little medium sand				94
95			dry	95.5' - 96' : Brown mottled fine sand and silt				95
96	95 ft to 100 ft		dry	96' - 100' : Tan medium to coarse sand, some fine sand, trace fine gravel				96
97								97
98								98
99								99
100				---------- End of Boring at 100' ----------				100

Project Number:	60476644	*Project Manager:* Tom Parece	AECOM 9 Jonathan Bourne Drive Pocasset, Massachusetts (508)-833-6950
Client:	Town of Orleans, MA	*Field Tech(s):* CH/MO/DD	
Site Location:	Route 6A Orleans, MA		

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:* Sonic Drilling	***Boring Number:***	**DU-2**	
Date	Monday, September 20, 2021		*Sheet:*		of
			Surface Elevation (ft-asl):	TBD	
Drill Contractor:	Redox Tech, LLC	*Equipment:* Geoprobe 8150LS	Boring Depth (ft):	100	
Date	Monday, September 20, 2021		*Inside Diameter (inches):*	2	
			Screen Depth:	N/A	
			Screen Length:	N/A	

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear 0 ft to 6 ft		dry	0' - 7' : Brown fine to coarse sand, some fine gravel, little roots				1
2								2
3								3
4								4
5								5
6	5 ft to 10 ft							6
7			dry	7' - 21' : Tan/brown fine to medium sand, some coarse sand, little fine gravel, slightly oxidized				7
8								8
9								9
10								10
11	10 ft to 15 ft					▼		11
12								12
13								13
14								14
15								15
16	15 ft to 20 ft							16
17								17
18								18
19								19
20								20
21	20 ft to 25 ft		dry	21' - 25' : Tan/light orange (slightly oxidized) medium to coarse sand, some fine sand, trace fine gravel thin brown silt layers a2 23' and 24'				21
22								22
23								23
24								24
25			dry	25' - 27' : Tan/brown fine to medium sand, some coarse sand, little fine gravel, slightly oxidized				25
26	25 ft to 30 ft							26
27			dry	27' -28' : Heavily oxidized brown fine sand and silt, very slightly plastic				27
28			dry	28' - 54' : Brown/ tan fine to medium sand, little coarse sand, trace fine gravel				28
29								29
30								30
31	30 ft to 35 ft							31
32								32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM
9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drilling	***Boring Number:***	**DU-2**
Date	Monday, September 20, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Monday, September 20, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft							36
37								37
38								38
39								39
40								40
41	40 ft to 45 ft							41
42								42
43								43
44								44
45								45
46	45 ft to 50 ft							46
47								47
48								48
49								49
50								50
51	50 ft to 55 ft							51
52								52
53								53
54			dry	54' - 60' : Brown silty fine sand, little medium sand				54
55								55
56	55 ft to 60 ft							56
57								57
58								58
59								59
60			dry	60' - 62' : brown/tan silt and sand, trace medium sand, non-plastic				60
61	60 ft to 65 ft							61
62			dry	62' - 63.5' : Brown clayey silt, very plastic, trace fine sand				62
63			dry	63.5' - 64' : Oxidized moderately, fine sand				63
64			dry	64' - 65.5' : Brown clayey silt, very plastic, trace fine sand				64
65								65
66	65 ft to 70 ft		dry	66.5' - 68' : Mottled brown fine sand, little silt				66
67								67
68			dry	68' - 76' : tan/brown fine to emdium sand, little coarse sand				68
69								69
70								70

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM

9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drilling	***Boring Number:***	**DU-2**
Date	Monday, September 20, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Monday, September 20, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft							71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft		dry	76' - 76.5' : rown clayey silt, very plastic, trace fine sand				76
			dry	76.5' - 78' : Brown fine sand, some silt, heavily oxidized, 2 " to 3 " thick clayey silt layer				
77								77
78			dry	78' - 85' : Tan fine to coarse sand, trace silt				78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83								83
84								84
85			dry	85' - 88' : brown/tan fine to medium sand, some coarse sand, trace silt				85
86	85 ft to 90 ft							86
87								87
88			dry	88' - 100' : Dark orange/brown medium to coarse sand, little fine sand, moderate to heavy oxidation				88
89								89
90								90
91	90 ft to 95 ft							91
92								92
93								93
94								94
95								95
96	95 ft to 100 ft							96
97								97
98								98
99								99
100				---------- End of Boring at 100' ----------				100

Project Number:	60476644	*Project Manager:* Tom Parece	AECOM 9 Jonathan Bourne Drive Pocasset, Massachusetts (508)-833-6950
Client:	Town of Orleans, MA	*Field Tech(s):* CH/MO/DD	
Site Location:	Route 6A Orleans, MA		

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:* Sonic Drill	***Boring Number:***	**DU-3**	
Date	Tuesday, August 31, 2021		*Sheet:*		of
			Surface Elevation (ft-asl):	TBD	
Drill Contractor:	Redox Tech, LLC	*Equipment:* Geoprobe 8150LS	Boring Depth (ft):	100	
Date	Wednesday, May 01, 2019		*Inside Diameter (inches):*	2	
			Screen Depth:	N/A	
			Screen Length:	N/A	

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear 0 ft to 6 ft		dry	0' - 6' : Brown, loose to medium dense fine to coarse sand, little fine gravel, trace coarse gravel A note from 9/21/21: 0' - 10' : No sample collected due to multiple utilities nearby				1
2								2
3								3
4								4
5								5
6	5 ft to 10 ft							6
7								7
8								8
9								9
10			dry	10' - 18' : Brown-tan fine to coarse sand, little fine gravel				10
11	10 ft to 15 ft							11
12								12
13								13
14								14
15								15
16	15 ft to 20 ft							16
17								17
18			dry	18' - 50' : Brown-tan fine to coarse sand, little fine gravel, mottled , wet at 30 ft, trace large gravel from 40 ft				18
19								19
20								20
21	20 ft to 25 ft							21
22								22
23								23
24								24
25								25
26	25 ft to 30 ft							26
27								27
28								28
29								29
30								30
31	30 ft to 35 ft							31
32								32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:* Tom Parece	AECOM 9 Jonathan Bourne Drive Pocasset, Massachusetts (508)-833-6950
Client:	Town of Orleans, MA	*Field Tech(s):* CH/MO/DD	
Site Location:	Route 6A Orleans, MA		

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:* Sonic Drill	***Boring Number:***	**DU-3**	
Date	Tuesday, August 31, 2021		*Sheet:*		of
			Surface Elevation (ft-asl):	TBD	
Drill Contractor:	Redox Tech, LLC	*Equipment:* Geoprobe 8150LS	Boring Depth (ft):	100	
Date	Wednesday, May 01, 2019		*Inside Diameter (inches):*	2	
			Screen Depth:	N/A	
			Screen Length:	N/A	

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft					▼		36
37								37
38								38
39								39
40								40
41	40 ft to 45 ft							41
42								42
43								43
44								44
45								45
46	45 ft to 50 ft							46
47								47
48								48
49								49
50			dry	50' - 54' : Brown-light tan fine to medium sand, mottled, trace coarse sand and fine gravel				50
51	50 ft to 55 ft							51
52								52
53								53
54			dry	54' - 60' : Brown fine to coarse sand, little fine gravel, trace coarse gravel				54
55								55
56	55 ft to 60 ft							56
57								57
58								58
59								59
60								60
61	60 ft to 65 ft							61
62								62
63								63
64								64
65								65
66	65 ft to 70 ft							66
67								67
68			dry	68' - 70' : Brown-light tan fine to medium sand, mottled, trace coarse sand, 0.5" brown silt at 70 ft				68
69								69
70			dry	70' - 83' : Brown-tan fine to medium sand, little coarse sand, trace fine gravel				70

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**DU-3**
Date	Tuesday, August 31, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Wednesday, May 01, 2019			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft							71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft							76
77								77
78								78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83			dry	83' - 87.5' : Brown fine sand and silt, heavy oxidation for 84 ft to bottom				83
84								84
85								85
86	85 ft to 90 ft							86
87			dry	87.5' - 88' : Brown -orange medium to coarse sand				87
88			dry	88' - 94.5' : Brown fine sand and silt, mottled, Brown thin clayey silt layers, moderate to heavy oxidation observed at 92 ft to 94.5 ft				88
89								89
90								90
91	90 ft to 95 ft							91
92								92
93								93
94			dry	94.5' - 100' : Brown fine sand, little silt, trace medium sand, moderate oxidation				94
95								95
96	95 ft to 100 ft							96
97								97
98								98
99								99
100				---------- End of Boring at 100' ----------				100

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**DU-4**
Date	Tuesday, August 31, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Wednesday, September 22, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear 0 ft to 6 ft		dry	0' - 2' : Tan fine to medium sand, little coarse sand, fine gravel, trace coarse gravel, medium dense gravel				1
2				2' - 6' : Brown, dense fine to coarse sand, fine gravel, little coarse gravel, trace silt				2
3								3
4								4
5								5
6	5 ft to 10 ft							6
7								7
8			dry	8' - 38' : Brown fine to coarse sand, some fine gravel, trace coarse gravel				8
9								9
10								10
11	10 ft to 15 ft							11
12								12
13								13
14								14
15								15
16	15 ft to 20 ft							16
17								17
18								18
19								19
20								20
21	20 ft to 25 ft							21
22								22
23								23
24								24
25								25
26	25 ft to 30 ft							26
27								27
28								28
29								29
30								30
31	30 ft to 35 ft							31
32								32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**DU-4**
Date	Tuesday, August 31, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Wednesday, September 22, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft							36
37						▼		37
38			dry	38' - 52' : Light brown-tan (slightly oxidized) fine to medium sand, little coarse sand, trace fine gravel, wet at 39 ft				38
39				(50' - 51' : Brown fine sand and silt, trace clay, mottled)				39
40								40
41	40 ft to 45 ft							41
42								42
43								43
44								44
45								45
46	45 ft to 50 ft							46
47								47
48								48
49								49
50								50
51	50 ft to 55 ft							51
52			dry	52' - 55' : Brown fine sand and silt, trace clay, mottled, moderately oxidized				52
53								53
54								54
55								55
56	55 ft to 60 ft		dry	55' - 60' : Tan medium to fine sand, little coarse sand, trace fine gravel				56
57								57
58								58
59								59
60			dry	60' - 62' : Light brown-tan fine to medium sand, little coarse sand, trace fine gravel,				60
61	60 ft to 65 ft							61
62			dry	62' - 66' : Brown silty fine sand, mottled				62
63								63
64								64
65								65
66	65 ft to 70 ft		dry	66' - 67' : Light brown-tan fine to medium sand, little coarse sand, trace fine gravel				66
67			dry	67' - 76' : Brown fine sand, some silt, mottled				67
68								68
69								69
70								70

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**DU-4**
Date	Tuesday, August 31, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Wednesday, September 22, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft							71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft		dry	76' - 89' : Brown fine to medium sand, trace coarse sand and fine gravel				76
77								77
78								78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83								83
84								84
85								85
86	85 ft to 90 ft							86
87								87
88								88
89			dry	89' - 96' : Brown fine sand, some silt, little medium sand				89
90								90
91	90 ft to 95 ft							91
92								92
93								93
94								94
95								95
96	95 ft to 100 ft		dry	96' - 100' : Dark brown-brown medium sand, little fine to coarse sand, trace fine gravel (97.5' - 98' : brown clayey silt)				96
97								97
98								98
99								99
100				---------- End of Boring at 100' ----------				100

Project Number:	60476644	*Project Manager:* Tom Parece	AECOM 9 Jonathan Bourne Drive Pocasset, Massachusetts (508)-833-6950
Client:	Town of Orleans, MA	*Field Tech(s):* CH/MO/DD	
Site Location:	Route 6A Orleans, MA		

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:* Sonic Drill	***Boring Number:***	**DU-5**	
Date	Tuesday, August 31, 2021		*Sheet:*	of	
			Surface Elevation (ft-asl):	TBD	
Drill Contractor:	Redox Tech, LLC	*Equipment:* Geoprobe 8150LS	Boring Depth (ft):	100	
Date	Thursday, September 23, 2021		*Inside Diameter (inches):*	2	
			Screen Depth:	N/A	
			Screen Length:	N/A	

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear 0 ft to 6 ft		dry	0' - 3' : Brown, medium dense to dense, fine to coarse sand, little fine gravel, trace coarse gravel				1
2			dry	3' - 6' : Brown, loose to medium dense, fine to coarse sand, little fine gravel, trace coarse gravel				2
3								3
4								4
5								5
6	5 ft to 10 ft		dry	6' - 10' : Tan-light orange fine to medium sand, some coarse sand and fine gravel				6
7								7
8								8
9								9
10			dry	10' - 27' : Brown-tan-light orange mottled fine to coarse sand, some fine gravel, wet at 20 ft (1/8 " oxidized layer)				10
11	10 ft to 15 ft							11
12								12
13								13
14								14
15								15
16	15 ft to 20 ft							16
17								17
18								18
19						▼		19
20								20
21	20 ft to 25 ft							21
22								22
23								23
24								24
25								25
26	25 ft to 30 ft							26
27			dry	27' - 38' : Brown medium to coarse sand, some fine gravel, little fine sand and coarse gravel, moderately oxidized from 26.5' to 27.5'				27
28								28
29								29
30								30
31	30 ft to 35 ft							31
32								32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:* Tom Parece	AECOM 9 Jonathan Bourne Drive Pocasset, Massachusetts (508)-833-6950
Client:	Town of Orleans, MA	*Field Tech(s):* CH/MO/DD	
Site Location:	Route 6A Orleans, MA		

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:* Sonic Drill	***Boring Number:***	**DU-5**	
Date	Tuesday, August 31, 2021		*Sheet:*		of
			Surface Elevation (ft-asl):	TBD	
Drill Contractor:	Redox Tech, LLC	*Equipment:* Geoprobe 8150LS	Boring Depth (ft):	100	
Date	Thursday, September 23, 2021		*Inside Diameter (inches):*	2	
			Screen Depth:	N/A	
			Screen Length:	N/A	

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft							36
37								37
38			dry	38' - 39' : Brown fine to medium sand, little coarse sand, trace fine gravel				38
39			dry	39' - 47.5' : Brown medium to coarse sand, some fine gravel, little fine sand and coarse gravel, medium to heavy oxidation				39
40								40
41	40 ft to 45 ft							41
42								42
43								43
44								44
45								45
46	45 ft to 50 ft							46
47			ry	47.5' - 50' : Brown fine to medium sand, little coarse sand, trace fine gravel				47
48								48
49								49
50			dry	50' - 55' : Brown silty fine sand, little medium sand				50
51	50 ft to 55 ft							51
52								52
53								53
54								54
55			ry	55' - 60' : Brown fine to medium sand,, little coarse sand, trace fine gravel				55
56	55 ft to 60 ft							56
57								57
58								58
59								59
60			dry	60' - 78' : Brown-tan medium to coarse sand, little fine sand, trace fine gravel (71.5' - 73.5' and 75.5' - 76' : Brown fine sand, some silt, trace medium sand)				60
61	60 ft to 65 ft							61
62								62
63								63
64								64
65								65
66	65 ft to 70 ft							66
67								67
68								68
69								69
70								70

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**DU-5**
Date	Tuesday, August 31, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Thursday, September 23, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft							71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft							76
77								77
78			dry	78' - 90' : Light brown fine sand, some silt, little medium sand, trace coarse sand				78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83								83
84								84
85								85
86	85 ft to 90 ft							86
87								87
88								88
89								89
90			dry	90' - 100' : Brown/ light orange medium to coarse sand, some fine sand, trace silt and fnie gravel				90
91	90 ft to 95 ft							91
92								92
93								93
94								94
95								95
96	95 ft to 100 ft							96
97								97
98								98
99								99
100				---------- End of Boring at 100' ----------				100

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM

9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill
Date	Tuesday, August 31, 2021		
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS
Date	Thursday, September 23, 2021		

Boring Number:	**DU-6**
Sheet:	of
Surface Elevation (ft-asl):	TBD
Boring Depth (ft):	100
Inside Diameter (inches):	2
Screen Depth:	N/A
Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear 0 ft		dry	0' - 6' : Brown/tan medium to coarse sand, little fine sand, some fine gravel, trace coarse gravvel, cobble medium sende				1
2	to 6 ft							2
3								3
4								4
5								5
6	5 ft		dry	5' - 10' : Tan/light gray fine silty sand, little medium sand and coarse sand, Trace fine gravel, wet at 6 ft				6
7	to 10 ft							7
8								8
9								9
10			dry	10' - 30' : Brown/ light orange fine to medium sand, some coarse sand, little fine to coarse gravel (slight to moderate oxidized)				10
11	10 ft							11
12	to 15 ft							12
13								13
14								14
15								15
16	15 ft							16
17	to 20 ft							17
18						▼		18
19								19
20								20
21	20 ft							21
22	to 25 ft							22
23								23
24								24
25								25
26	25 ft							26
27	to 30 ft							27
28								28
29								29
30			dry dry	30' - 30.5' : Brown fine sand, some medium sand, trace coarse sand 30.5' - 46' : Brown/tan fine to coarse sand, little fine gravel				30
31	30 ft							31
32	to 35 ft							32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM
9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**DU-6**
Date	Tuesday, August 31, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Thursday, September 23, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft							36
37								37
38								38
39								39
40			dry	46' - 54' : Brown/tan fine to medium sand, some coarse sand, trace fine to coarse gravel, moderate oxidation				40
41	40 ft to 45 ft							41
42								42
43								43
44								44
45								45
46	45 ft to 50 ft							46
47								47
48								48
49								49
50								50
51	50 ft to 55 ft							51
52								52
53								53
54			dry	54' - 74' : Brown-tan fine to medium sand, some coarse sand, little fine to coarse gravel				54
55								55
56	55 ft to 60 ft							56
57								57
58								58
59								59
60								60
61	60 ft to 65 ft							61
62								62
63								63
64								64
65								65
66	65 ft to 70 ft							66
67								67
68								68
69								69
70								70

Project Number:	60476644	*Project Manager:* Tom Parece	AECOM 9 Jonathan Bourne Drive Pocasset, Massachusetts (508)-833-6950
Client:	Town of Orleans, MA	*Field Tech(s):* CH/MO/DD	
Site Location:	Route 6A Orleans, MA		

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:* Sonic Drill	***Boring Number:***	**DU-6**	
Date	Tuesday, August 31, 2021		*Sheet:*		of
			Surface Elevation (ft-asl):	TBD	
Drill Contractor:	Redox Tech, LLC	*Equipment:* Geoprobe 8150LS	Boring Depth (ft):	100	
Date	Thursday, September 23, 2021		*Inside Diameter (inches):*	2	
			Screen Depth:	N/A	
			Screen Length:	N/A	

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft							71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft		ry	76' - 77' : Brown medium sand, some fine sand, trace coarse sand and fine gravel				76
77			dry	77' - 78' : Brown-tan fine sand, mottled, little silt				77
78			dry	78' - 83' : Brown-tan fine to medium sand, some coarse sand, little fine to coarse gravel				78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83			dry	83' - 100' : Brown fine to very fine sand, some silt, trace medium sand, clayey silt at 83.5 ft				83
84								84
85								85
86	85 ft to 90 ft							86
87								87
88								88
89								89
90								90
91	90 ft to 95 ft							91
92								92
93								93
94								94
95								95
96	95 ft to 100 ft							96
97								97
98								98
99								99
100				---------- End of Boring at 100' ----------				100

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**NA-1**
Date	Tuesday, August 31, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Thursday, September 30, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear 0 ft to 6 ft		dry	0' - 6' : loose tan/light brown medium sand, little fine to coarse sand, trace fine gravel				1
2								2
3								3
4								4
5								5
6	5 ft to 10 ft		dry	6' - 46' : Tan fine sand, little medium sand, trace coarse sand and fine gravel				6
7								7
8								8
9								9
10								10
11	10 ft to 15 ft							11
12								12
13								13
14								14
15								15
16	15 ft to 20 ft							16
17								17
18								18
19								19
20								20
21	20 ft to 25 ft							21
22								22
23								23
24								24
25								25
26	25 ft to 30 ft							26
27								27
28								28
29								29
30								30
31	30 ft to 35 ft							31
32								32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM
9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**NA-1**
Date	Tuesday, August 31, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Thursday, September 30, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft							36
37								37
38								38
39								39
40								40
41	40 ft to 45 ft							41
42								42
43								43
44								44
45								45
46	45 ft to 50 ft		drdy	46' - 58' : Brown-tan fine sand, some silt, little medium sand, trace coarse sand (54.75' to 55' and 55.5' to 56' : Gray-brown mottled sandy silt, dense)				46
47								47
48								48
49								49
50								50
51	50 ft to 55 ft							51
52								52
53								53
54								54
55								55
56	55 ft to 60 ft							56
57								57
58			dry	58' - 67' : Tan-light orange medium to coarse sand, some fine gravel, little fine sand, wet at 66 ft				58
59								59
60								60
61	60 ft to 65 ft							61
62								62
63								63
64						▼		64
65								65
66	65 ft to 70 ft							66
67			dry	67' - 67.5' : Dense brown, slightly oxidized silt, some fine sand, little medium sand, trace gravel and cobble				67
68			dry	67.5' - 89' : Tan-light brown medium to coarse sand, trace fine gravel				68
69								69
70								70

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM

9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**NA-1**
Date	Tuesday, August 31, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Thursday, September 30, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft							71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft							76
77								77
78								78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83								83
84								84
85								85
86	85 ft to 90 ft							86
87								87
88								88
89			dry	89' - 92' : Brown very dense silt, little fine sand, trace clay, non plastic				89
90								90
91	90 ft to 95 ft							91
92								92
93								93
94								94
95								95
96	95 ft to 100 ft							96
97								97
98								98
99								99
100				---------- End of Boring at 100' ----------				100

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM

9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonid Drill
Date	Wednesday, September 01, 2021		
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS
Date	Friday, October 01, 2021		

Boring Number:	**NA-2**
Sheet:	of
Surface Elevation (ft-asl):	TBD
Boring Depth (ft):	100
Inside Diameter (inches):	2
Screen Depth:	N/A
Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear 0 ft to 6 ft		dry	0' - 6' : Tan fine to medium sand, trace fine to coarse gravel, cobble, little coarse sand				1
2								2
3								3
4								4
5								5
6	5 ft to 10 ft		dry	6' - 11' : Tan medium sand, some fine sand, trace coarse sand, wet at 10 ft		▼		6
7								7
8								8
9								9
10								10
11	10 ft to		dry	11' - 12' : Brown-dark orange coarse sand, some medium sand, trace fine sand				11
12	15 ft		dry	12' - 26' : Brown fine to medium sand, little coarse sand, trace fine gravel				12
13								13
14								14
15								15
16	15 ft to							16
17	20 ft							17
18								18
19								19
20								20
21	20 ft to							21
22	25 ft							22
23								23
24								24
25								25
26	25 ft to		dry dry	26' - 26.5' : Brown fine sand, little medium sand, trace coarse sand 26.5' - 55' : Dark brown medium to coarse sand, little fine sand and fine gravel (trace coarse gravel 50' - 55')				26
27	30 ft			(Dark brown coarse sand and fine gravel, some medium sand 53' - 55')				27
28								28
29								29
30								30
31	30 ft to							31
32	35 ft							32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonid Drill	***Boring Number:***	**NA-2**
Date	Wednesday, September 01, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Friday, October 01, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft							36
37								37
38								38
39								39
40								40
41	40 ft to 45 ft							41
42								42
43								43
44								44
45								45
46	45 ft to 50 ft							46
47								47
48								48
49								49
50								50
51	50 ft to 55 ft							51
52								52
53								53
54								54
55								55
56	55 ft to 60 ft		dry dry	55' - 56.5' : Dense brown-tan silt, some fine sand, mottled, ends on heavily oxidized 56.5' - 66.5' : Tan fine to medium sand, little coarse sand (57' - 57.5' : Brown fine sand-------65' - 66.5' : Heavy oxidation)				56
57								57
58								58
59								59
60								60
61	60 ft to 65 ft							61
62								62
63								63
64								64
65								65
66	65 ft to 70 ft		dry dry	66.5' - 67' : Brown fine sand and silt, dense 67' - 89' : Brown fine sand, some silt, little medium sand, trace coarse sand and fine gravel (67' - 73' : Slightly oxidized)				66
67								67
68								68
69								69
70								70

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM
9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonid Drill	***Boring Number:***	**NA-2**
Date	Wednesday, September 01, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Friday, October 01, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft							71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft							76
77								77
78								78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83								83
84								84
85								85
86	85 ft to 90 ft							86
87								87
88								88
89			dry	89' - 89.3' : Brown silt and clay, very plastic				89
90			dry	89.3' - 100' : Brown mottled fine sand and silt, dense				90
91	90 ft to 95 ft							91
92								92
93								93
94								94
95								95
96	95 ft to 100 ft							96
97								97
98								98
99								99
100				---------- End of Boring at 100' ----------				100

Project Number:	60476644	*Project Manager:* Tom Parece	AECOM 9 Jonathan Bourne Drive Pocasset, Massachusetts (508)-833-6950
Client:	Town of Orleans, MA	*Field Tech(s):* CH/MO/DD	
Site Location:	Route 6A Orleans, MA		

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:* Sonic Drill	***Boring Number:***	**PS-1**	
Date	Friday, September 24, 2021		*Sheet:*		of
			Surface Elevation (ft-asl):	TBD	
Drill Contractor:	Redox Tech, LLC	*Equipment:* Geoprobe 8150LS	Boring Depth (ft):	58	
Date	Friday, September 24, 2021		*Inside Diameter (inches):*	2	
			Screen Depth:	N/A	
			Screen Length:	N/A	

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description				Depth
1	Pre-Clear 0 ft to 6 ft		dry	0' - 8' : Tan fine to medium sand, little coarse sand, trace fine gravel				1
2								2
3								3
4								4
5								5
6	5 ft to 10 ft							6
7								7
8			dry	8' - 15' : Tan fine to medium sand, little coarse sand, trace fine gravel				8
9								9
10								10
11	10 ft to 15 ft							11
12								12
13								13
14								14
15			dry	15' - 17' : Brown-light gray fine sand and silt, trace medium to coarse sand and gravel				15
16	15 ft to 20 ft							16
17			dry	17' - 23.5' : Brown fine to coarse sand, little fine gravel, trace coarse gravel, wet @ 23 ft				17
18								18
19								19
20								20
21	20 ft to 25 ft							21
22								22
23			dry	23.5' - 26' : Tan fine to medium sand, little coarse sand and fine gravel				23
24								24
25								25
26	25 ft to 30 ft		dry	26' - 28' : Brown-gray fine sand and silt, little medium to coarse sand, trace fine gravel, very dense				26
27								27
28			dry	28' - 47' : Brown medium to coarse sand, some fine sand and gravel, trace coarse gravel and cobble				28
29								29
30								30
31	30 ft to 35 ft							31
32								32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**PS-1**
Date	Friday, September 24, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	58
Date	Friday, September 24, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description				Depth
36	35 ft to 40 ft							36
37								37
38								38
39								39
40								40
41	40 ft to 45 ft							41
42								42
43								43
44								44
45								45
46	45 ft to 50 ft		dry	47' - 56' : Brown fine sand, little medium sand, trace coarse sand and gravel				46
47								47
48								48
49								49
50								50
51	50 ft to 55 ft							51
52								52
53								53
54								54
55								55
56	55 ft to 60 ft		dry	56' - 57.5' : Brown silt, dense, trace fine sand				56
57			dry	57.5' - 58' : Gray, very dense clay, plastic				57
58				---------- End of Boring at 58' ----------				58
59								59
60								60
61	60 ft to 65 ft							61
62								62
63								63
64								64
65								65
66	65 ft to 70 ft							66
67								67
68								68
69								69
70								70

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM

9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill
Date	Friday, September 24, 2021		
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS
Date	Friday, September 24, 2021		

Boring Number:	**PS-1**
Sheet:	of
Surface Elevation (ft-asl):	TBD
Boring Depth (ft):	58
Inside Diameter (inches):	2
Screen Depth:	N/A
Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description				Depth
71	70 ft to 75 ft							71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft							76
77								77
78								78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83								83
84								84
85								85
86	85 ft to 90 ft							86
87								87
88								88
89								89
90								90
91	90 ft to 95 ft							91
92								92
93								93
94								94
95								95
96	95 ft to 100 ft							96
97								97
98								98
99								99
100								100
101	100 ft to 105 ft							101
102								102
103								103
104								104
105								105

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM

9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**PS-2**
Date	Friday, September 24, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	58
Date	Friday, September 24, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description				Depth
1	Pre-Clear 0 ft to 6 ft		dry	0' - 19' : Tan fine to medium sand, trace coarse sand and fine gravel				1
2								2
3								3
4								4
5								5
6	5 ft to 10 ft							6
7								7
8								8
9								9
10								10
11	10 ft to 15 ft							11
12								12
13								13
14								14
15								15
16	15 ft to 20 ft							16
17								17
18								18
19			dry	19' - 20' : Brown-gray fine sand, little medium sand, trace fine to coarse gravel				19
20			dry	20' - 24' : Gray-brown fine sand and silt, trace medium to coarse sand and gravel, wet @ 23 ft				20
21	20 ft to 25 ft							21
22								22
23								23
24			dry	24' - 26' : Brown fine to coarse sand, little fine gravel, trace coarse gravel				24
25								25
26	25 ft to 30 ft		dry	26' - 28' : Brown-light gray fine sand and silt, little medium to coarse sand, trace fine gravel, dense				26
27								27
28			dry	28' - 30' : Brown (slightly oxidized) medium to coarse sand, some fine sand and gravel				28
29								29
30			dry	30' - 34' : Very dense brown silt, some fine sand, trace medium to coarse sand, gray clay				30
31	30 ft to 35 ft							31
32								32
33								33
34			dry	34' - 37' : Heavily oxidized orange-red fine to medium sand, little coarse sand, trace fine gravel				34
35								35

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**PS-2**
Date	Friday, September 24, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	58
Date	Friday, September 24, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description				Depth
36	35 ft to 40 ft		ry	37' - 49' : Brown medium to coarse sand, some fine gravel, loose (47' to 48' : Gray fine to medium sand)				36
37								37
38								38
39								39
40								40
41	40 ft to 45 ft							41
42								42
43								43
44								44
45								45
46	45 ft to 50 ft							46
47								47
48								48
49			dry	49' - 57' : Brown fine sand, little medium sand, trace coarse sand and gravel, gray clay at 57 ft (3" to 4")				49
50								50
51	50 ft to 55 ft							51
52								52
53								53
54								54
55								55
56	55 ft to 60 ft		dry	57' - 58' : Brown-orange moderately oxidized fine to medium sand, trace coarse sand				56
57								57
58				---------- End of Boring at 58' ----------				58
59								59
60								60
61	60 ft to 65 ft							61
62								62
63								63
64								64
65								65
66	65 ft to 70 ft							66
67								67
68								68
69								69
70								70

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM

9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**PS-2**
Date	Friday, September 24, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	58
Date	Friday, September 24, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description				Depth
71	70 ft to 75 ft							71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft							76
77								77
78								78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83								83
84								84
85								85
86	85 ft to 90 ft							86
87								87
88								88
89								89
90								90
91	90 ft to 95 ft							91
92								92
93								93
94								94
95								95
96	95 ft to 100 ft							96
97								97
98								98
99								99
100								100
101	100 ft to 105 ft							101
102								102
103								103
104								104
105								105

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**RI-1**
Date	Tuesday, August 31, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	105
Date	Thursday, September 30, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear 0 ft to 6 ft		dry	0' - 6' : Fine to medium sand, tan				1
2								2
3								3
4								4
5								5
6	5 ft to 10 ft		dry	7' - 46' : Tan-light brown fine sand, little medium sand, trace coarse sand				6
7								7
8								8
9								9
10								10
11	10 ft to 15 ft							11
12								12
13								13
14								14
15								15
16	15 ft to 20 ft							16
17								17
18								18
19								19
20								20
21	20 ft to 25 ft							21
22								22
23								23
24								24
25								25
26	25 ft to 30 ft							26
27								27
28								28
29								29
30								30
31	30 ft to 35 ft							31
32								32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:* Tom Parece	AECOM 9 Jonathan Bourne Drive Pocasset, Massachusetts (508)-833-6950
Client:	Town of Orleans, MA	*Field Tech(s):* CH/MO/DD	
Site Location:	Route 6A Orleans, MA		

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:* Sonic Drill	***Boring Number:***	**RI-1**	
Date	Tuesday, August 31, 2021		*Sheet:*		of
			Surface Elevation (ft-asl):	TBD	
Drill Contractor:	Redox Tech, LLC	*Equipment:* Geoprobe 8150LS	Boring Depth (ft):	105	
Date	Thursday, September 30, 2021		*Inside Diameter (inches):*	2	
			Screen Depth:	N/A	
			Screen Length:	N/A	

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft							36
37								37
38								38
39								39
40			dry	46' - 50' : Tan-light brown fine to medium sand, trace coarse sand				40
41	40 ft to 45 ft							41
42								42
43								43
44								44
45								45
46	45 ft to 50 ft							46
47								47
48								48
49								49
50			dry	50' - 52' : Tan-light brown fine sand, little medium sand, trace coarse sand				50
51	50 ft to 55 ft							51
52			dry dry	52' - 52.5' : Brown, mottled dense fine sand and silt 52.5' - 54' : Loose tan fine sand				52
53								53
54			dry	54' - 58' : Loose tan fine sand				54
55								55
56	55 ft to 60 ft							56
57								57
58			dry	58' - 67' : Light brown fine sand, little silt, trace medium to coarse sand				58
59								59
60								60
61	60 ft to 65 ft							61
62								62
63								63
64								64
65								65
66	65 ft to 70 ft							66
67			dry	67' - 76' : Brown-light brown fine sand, trace medium to coarse sand and silt				67
68								68
69								69
70								70

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM

9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill
Date	Tuesday, August 31, 2021		
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS
Date	Thursday, September 30, 2021		

Boring Number:	**RI-1**
Sheet:	of
Surface Elevation (ft-asl):	TBD
Boring Depth (ft):	105
Inside Diameter (inches):	2
Screen Depth:	N/A
Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft							71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft		dry	76' - 94' : Dense brown-light gray silt, some fine sand, trace medium to coarse sand (93' - 93.5' : Medium sand, little fine sand)				76
77								77
78								78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83								83
84								84
85								85
86	85 ft to 90 ft					▼		86
87								87
88								88
89								89
90								90
91	90 ft to 95 ft							91
92								92
93								93
94			dry	94' - 94.5' : Tan fine to medium sand, trace coarse sand and silt				94
95			dry	94.5' - 99' : Very dense light gray-brown mottled silt, trace fine to coarse sand (96.5' - 97.5' : Fine to coarse sand)				95
96	95 ft to 100 ft							96
97								97
98								98
99			dry	99' - 105' : Light brown-tan medium to coarse sand, little fine sand, wet at 93 ft				99
100								100
101	100 ft to 105 ft							101
102								102
103								103
104								104
105				---------- End of Boring at 105' ----------				105

Project Number:	60476644	*Project Manager:*	Tom Parece
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD
Site Location:	Route 6A Orleans, MA		

AECOM

9 Jonathan Bourne Drive
Pocasset, Massachusetts
(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill
Date	Saturday, September 25, 2021		
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS
Date	Saturday, September 25, 2021		

Boring Number:	**RI-2**
Sheet:	of
Surface Elevation (ft-asl):	TBD
Boring Depth (ft):	100
Inside Diameter (inches):	2
Screen Depth:	N/A
Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear		dry	0' - 0.5' : Dark brown topsoil and grass				1
2	0 ft to 6 ft		dry	0.5' -22' : Tan-brown fine to medium sand, some coarse sand, little fine gravel, trace coarse gravel				2
3								3
4								4
5								5
6	5 ft to 10 ft							6
7								7
8								8
9								9
10								10
11	10 ft to 15 ft							11
12								12
13								13
14								14
15								15
16	15 ft to 20 ft							16
17								17
18								18
19								19
20								20
21	20 ft to 25 ft							21
22			dry	22'-26' : Brown mottled silty fine sand, little medium sand, slightly oxidized				22
23								23
24								24
25								25
26	25 ft to 30 ft		dry	26' - 28' : Heavily oxidized orange fine to medium sand, some silt				26
27								27
28			dry	28' - 32' : Brown fine to medium sand , little coarse sand and silt, trace fine gravel, wet at 29.5 ft				28
29						▼		29
30								30
31	30 ft to 35 ft							31
32			dry	32' 44' : Brown-tan medium to coarse sand, some fine gravel, little fine sand, trace coarse gravel				32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**RI-2**
Date	Saturday, September 25, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Saturday, September 25, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft							36
37								37
38								38
39								39
40								40
41	40 ft to 45 ft							41
42								42
43								43
44			dry	44' - 60' : Tan fine to medium sand, little coarse sand, trace fine to coarse gravel and cobble (cobble at 55 ft)				44
45								45
46	45 ft to 50 ft							46
47								47
48								48
49								49
50								50
51	50 ft to 55 ft							51
52								52
53								53
54								54
55								55
56	55 ft to 60 ft							56
57								57
58								58
59								59
60								60
61	60 ft to 65 ft							61
62				60 - 63 Brown Fine Sand and Silt,Little medium to coarse Sand, 1" layer stiff plastic clay. @ 60 ft.				62
63								63
64								64
65								65
66	65 ft to 70 ft							66
67				63 - 88" Dark Grey Fine Sand and Silt, very dense, trace medium to coarse sand (72 to 75'), transitions to brown in color.				67
68								68
69								69
70								70

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**RI-2**
Date	Saturday, September 25, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Saturday, September 25, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft							71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft							76
77								77
78								78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83								83
84								84
85								85
86	85 ft to 90 ft							86
87								87
88								88
89				---------- End of Boring at 88' ----------				89
90								90
91	90 ft to 95 ft							91
92								92
93								93
94								94
95								95
96	95 ft to 100 ft							96
97								97
98								98
99								99
100								100

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**RI-3**
Date	Wednesday, September 29, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Wednesday, September 29, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
1	Pre-Clear 0 ft to 6 ft		dry dry	0' - 1.5' : topsoil 1.5' - 42' : Tan fine to medium sand, trace coarse sand and fine gravel, wet @ 41 ft				1
2								2
3								3
4								4
5								5
6	5 ft to 10 ft							6
7								7
8								8
9								9
10								10
11	10 ft to 15 ft							11
12								12
13								13
14								14
15								15
16	15 ft to 20 ft							16
17								17
18								18
19								19
20								20
21	20 ft to 25 ft							21
22								22
23								23
24								24
25								25
26	25 ft to 30 ft							26
27								27
28								28
29								29
30								30
31	30 ft to 35 ft							31
32								32
33								33
34								34
35								35

Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**RI-3**
Date	Wednesday, September 29, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Wednesday, September 29, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
36	35 ft to 40 ft							36
37								37
38								38
39								39
40								40
41	40 ft to 45 ft							41
42			dry	42' - 64' : Tan-light brown fine to coarse sand, trace silt and fine gravel (1/2" gray fine sand and silt at 47 ft)				42
43				(Brown fine to medium sand, little coarse sand 61' - 61.5')				43
44								44
45								45
46	45 ft to 50 ft							46
47								47
48								48
49								49
50								50
51	50 ft to 55 ft							51
52								52
53								53
54								54
55								55
56	55 ft to 60 ft							56
57								57
58								58
59								59
60								60
61	60 ft to 65 ft							61
62						▼		62
63								63
64			dry	64' - 65' : Brown fine to medium sand, little coarse sand				64
65			dry	65' - 78' : Tan-light brown fine to coarse sand, trace silt and fine gravel				65
66	65 ft to 70 ft							66
67								67
68								68
69								69
70								70

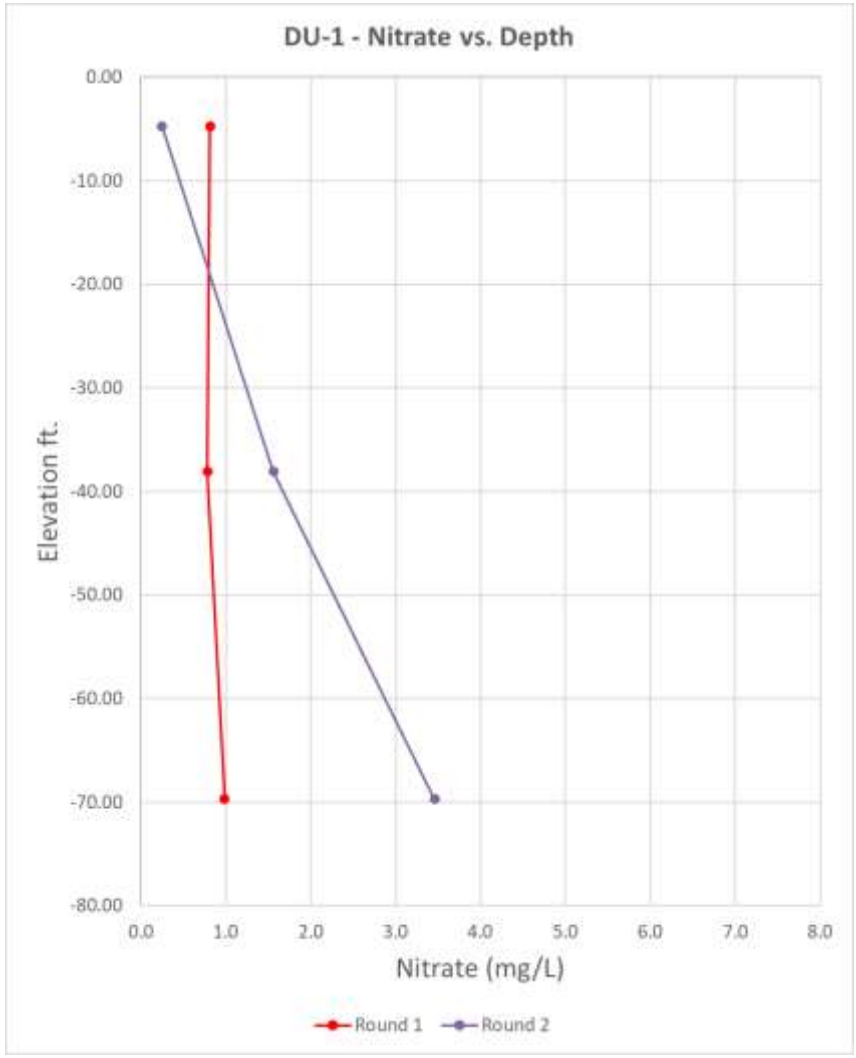
Project Number:	60476644	*Project Manager:*	Tom Parece	AECOM	9 Jonathan Bourne Drive
Client:	Town of Orleans, MA	*Field Tech(s):*	CH/MO/DD		Pocasset, Massachusetts
Site Location:	Route 6A Orleans, MA				(508)-833-6950

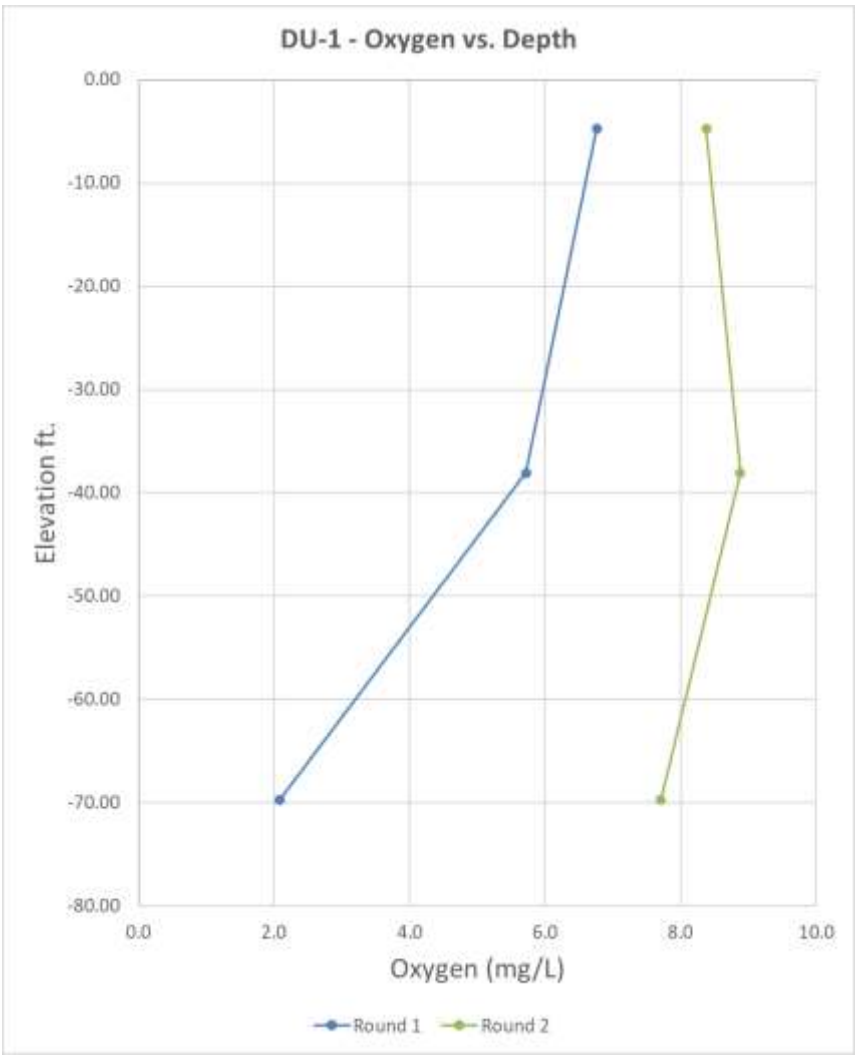
Pre-Clear Contractor:	Subsurface Exploration Services, LLC	*Equipment:*	Sonic Drill	***Boring Number:***	**RI-3**
Date	Wednesday, September 29, 2021			*Sheet:*	of
				Surface Elevation (ft-asl):	TBD
Drill Contractor:	Redox Tech, LLC	*Equipment:*	Geoprobe 8150LS	Boring Depth (ft):	100
Date	Wednesday, September 29, 2021			*Inside Diameter (inches):*	2
				Screen Depth:	N/A
				Screen Length:	N/A

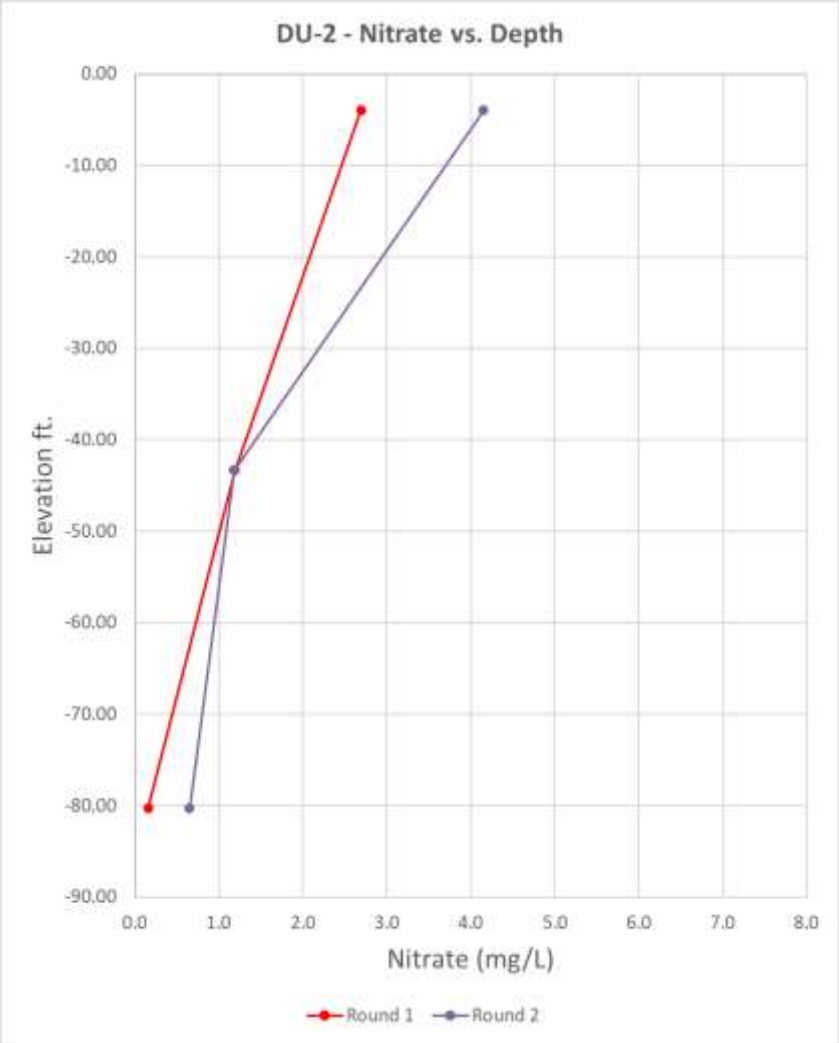
Depth	Sample Interval	Rec (ft)	Moisture	Field Identification / Description	Shallow	Interm.	Deep	Depth
71	70 ft to 75 ft							71
72								72
73								73
74								74
75								75
76	75 ft to 80 ft							76
77								77
78			dry	78' - 87' : Brown fine sand, some medium sand, trace coarse sand, little silt				78
79								79
80								80
81	80 ft to 85 ft							81
82								82
83								83
84								84
85								85
86	85 ft to 90 ft							86
87			ry	87' - 100' : Brown very fine to fine sand, little to some silt, fine to medium sand				87
88								88
89								89
90								90
91	90 ft to 95 ft							91
92								92
93								93
94								94
95								95
96	95 ft to 100 ft							96
97								97
98								98
99								99
100				---------- End of Boring at 100' ----------				100

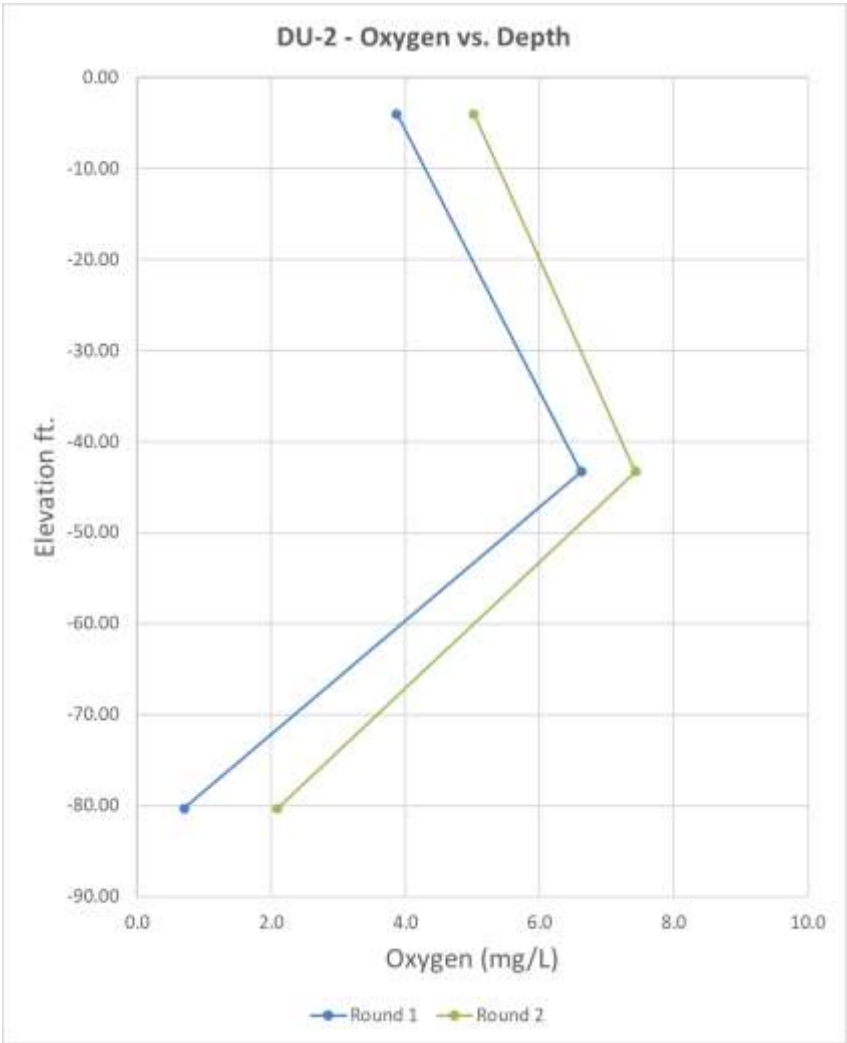
Appendix D: Charts

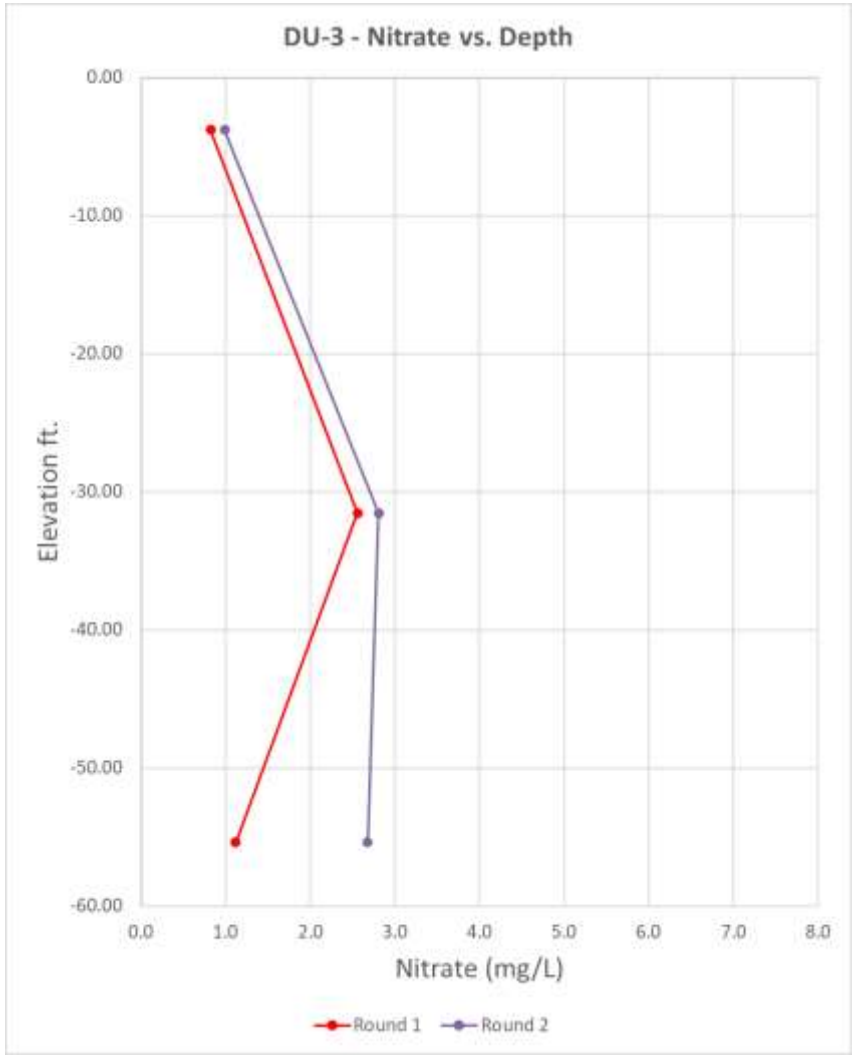
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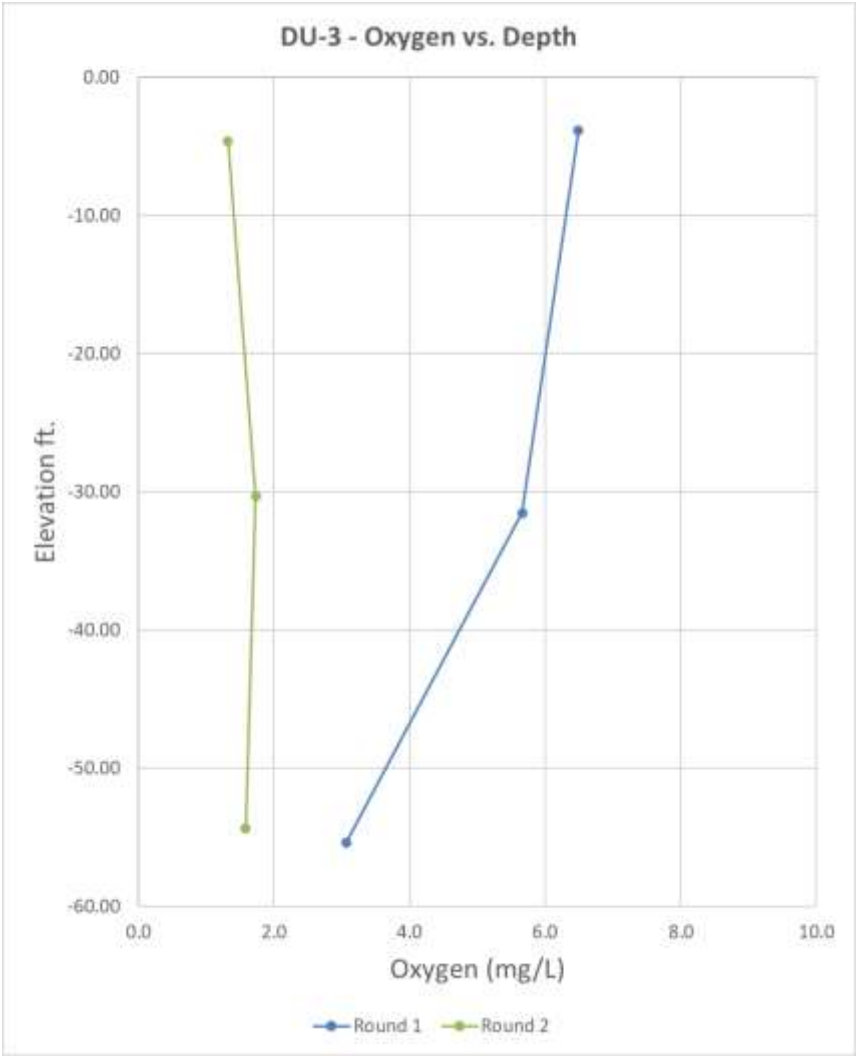

DU-1 - Nitrate vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2

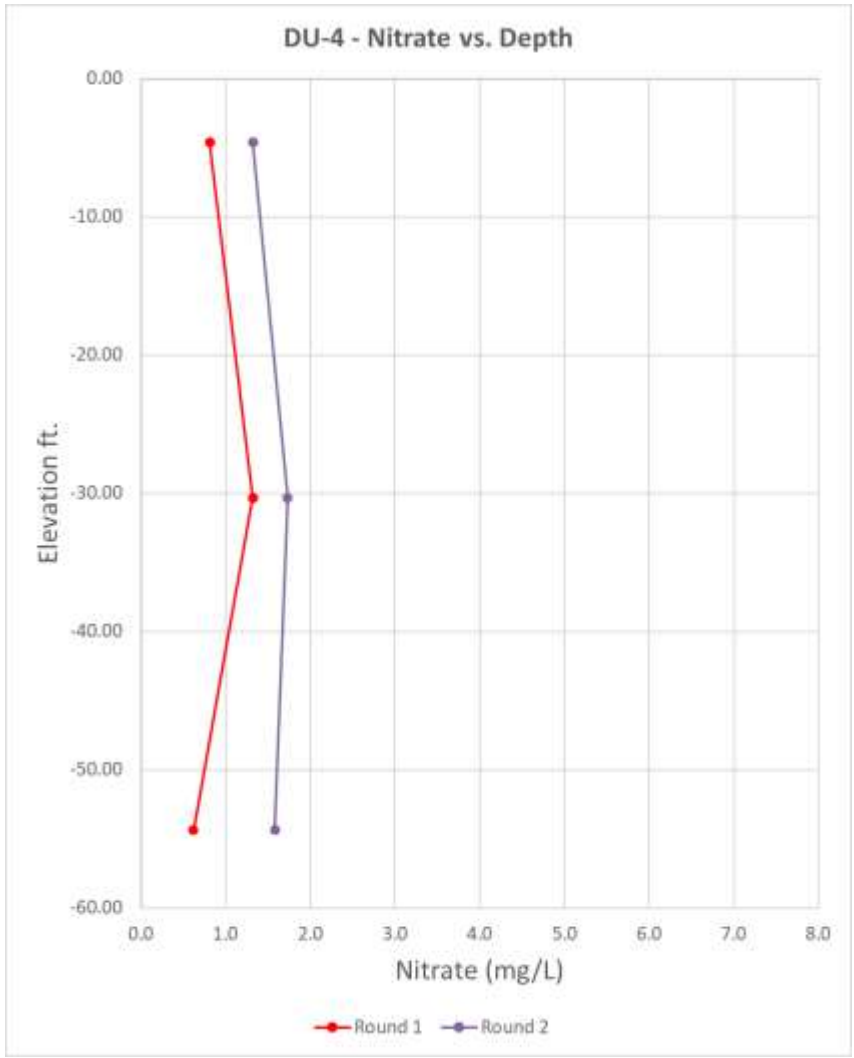

DU-1 - Oxygen vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
Elevation ft.
0.0
2.0
4.0
6.0
8.0
10.0
Oxygen (mg/L)
Round 1
Round 2

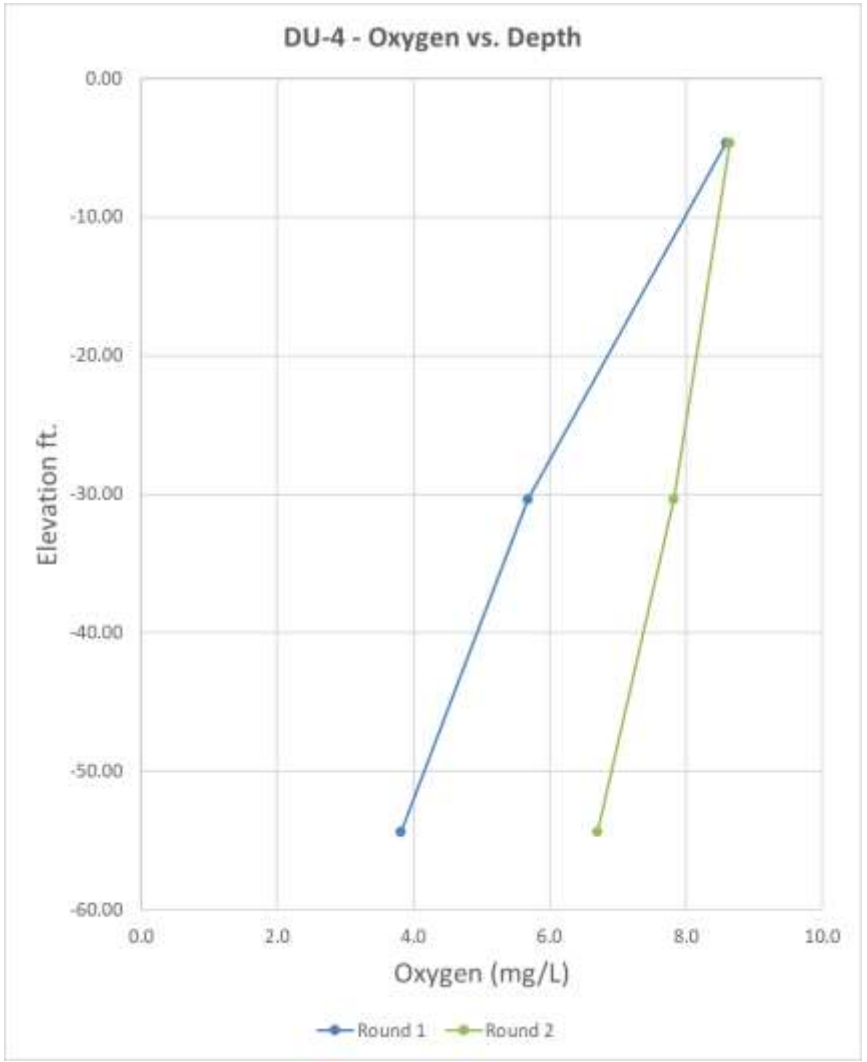

DU-2 - Nitrate vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
-90.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2

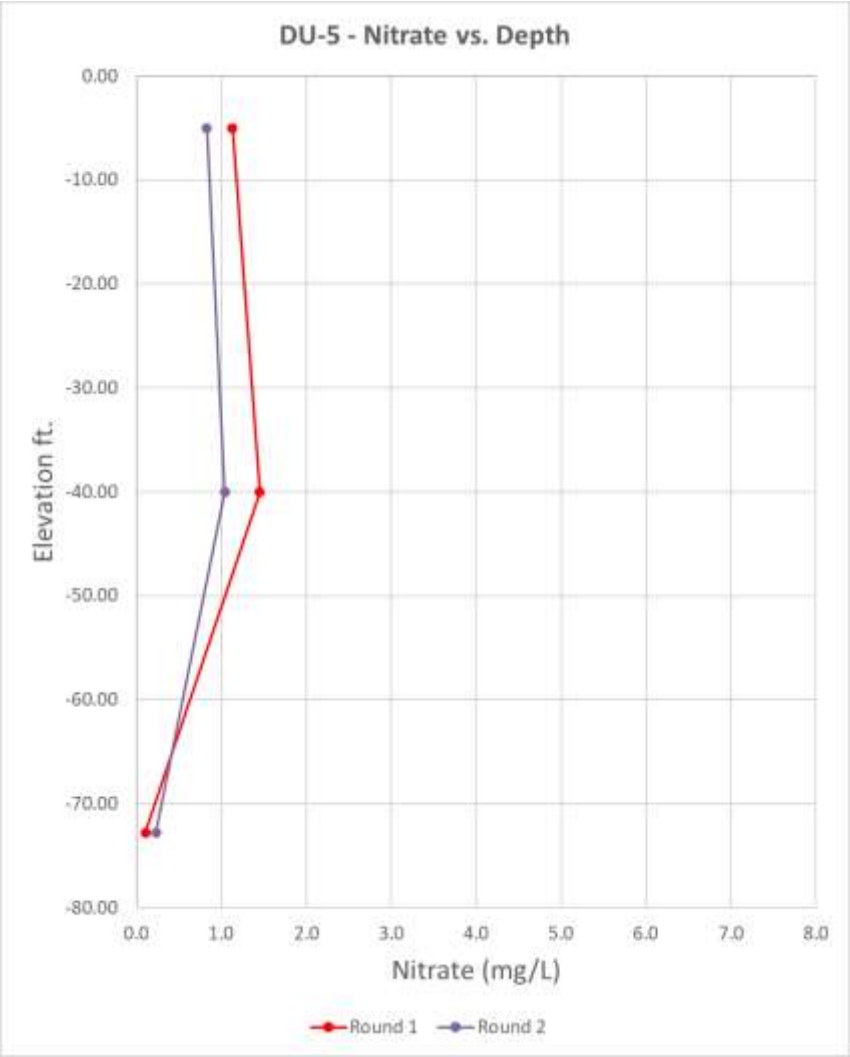

DU-2 - Oxygen vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
-90.00
Elevation ft.
0.0
2.0
4.0
6.0
8.0
10.0
Oxygen (mg/L)
Round 1
Round 2

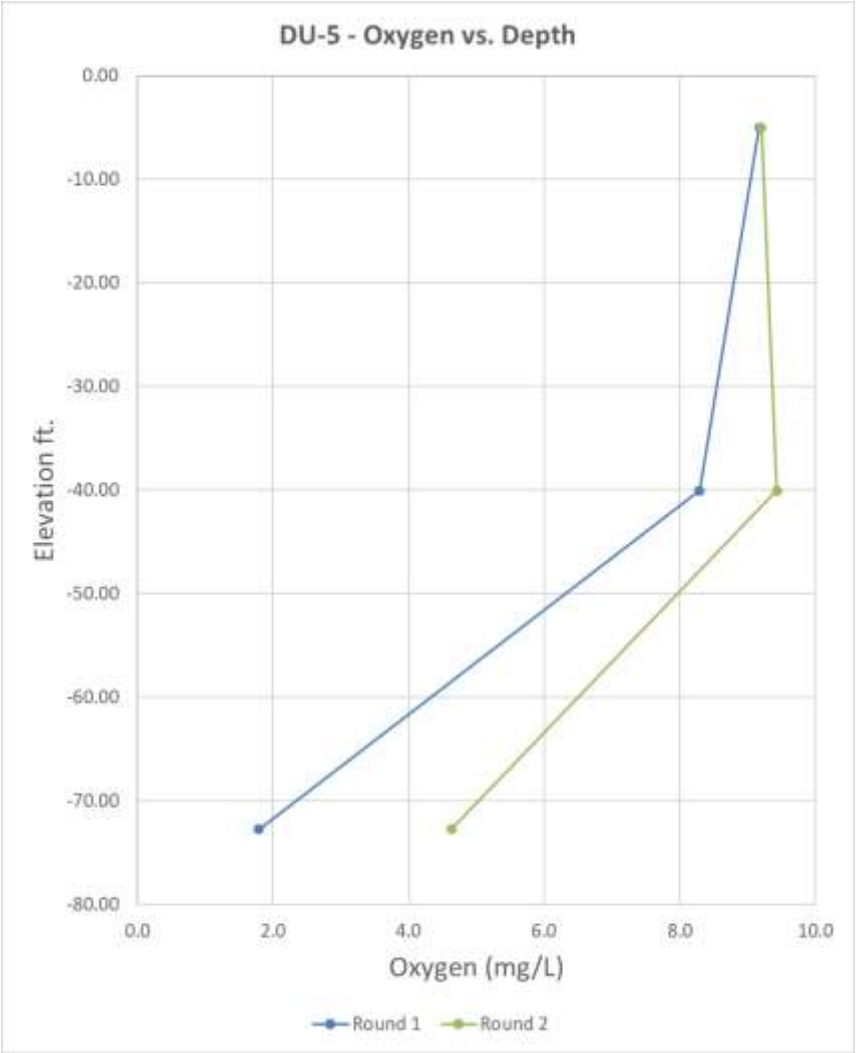

DU-3 - Nitrate vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2

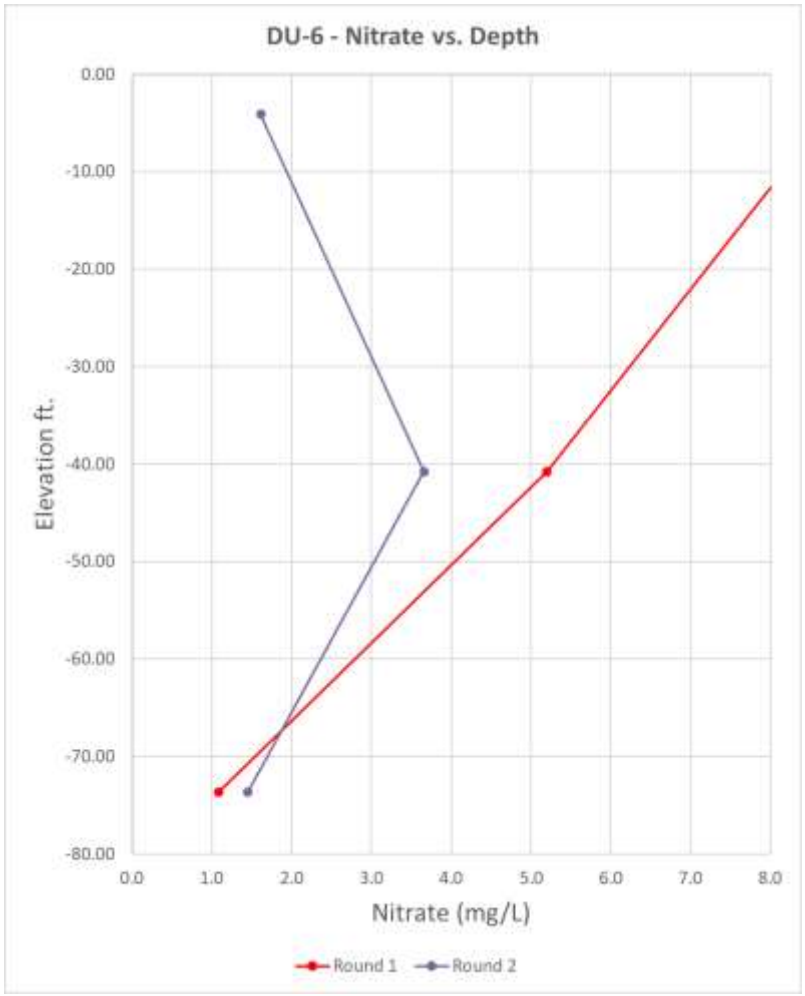

DU-3 - Oxygen vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
Elevation ft.
0.0
2.0
4.0
6.0
8.0
10.0
Oxygen (mg/L)
Round 1
Round 2

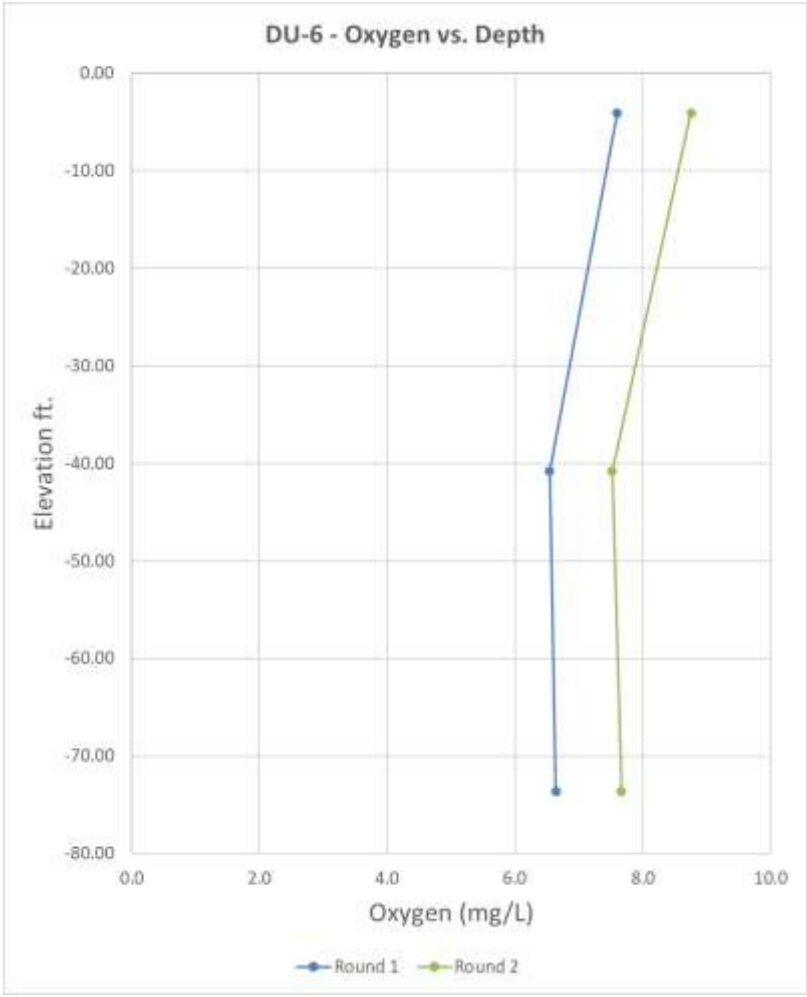

DU-4 - Nitrate vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2

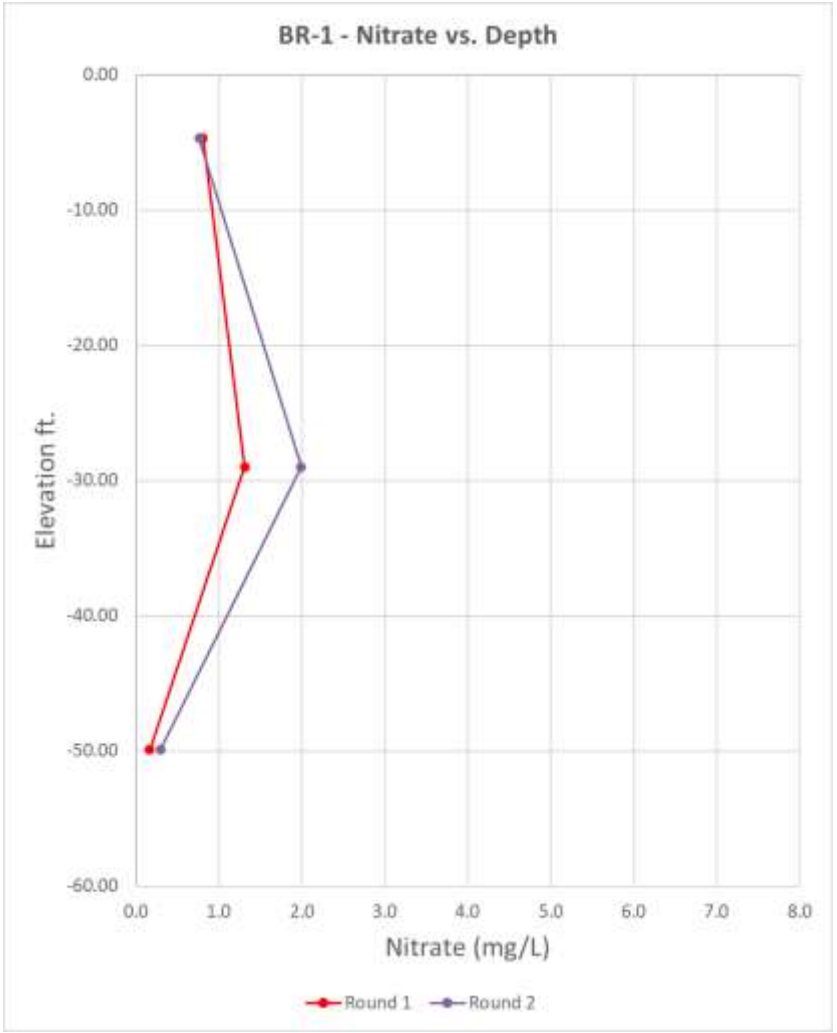

DU-4 - Oxygen vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
Elevation ft.
0.0
2.0
4.0
6.0
8.0
10.0
Oxygen (mg/L)
Round 1
Round 2

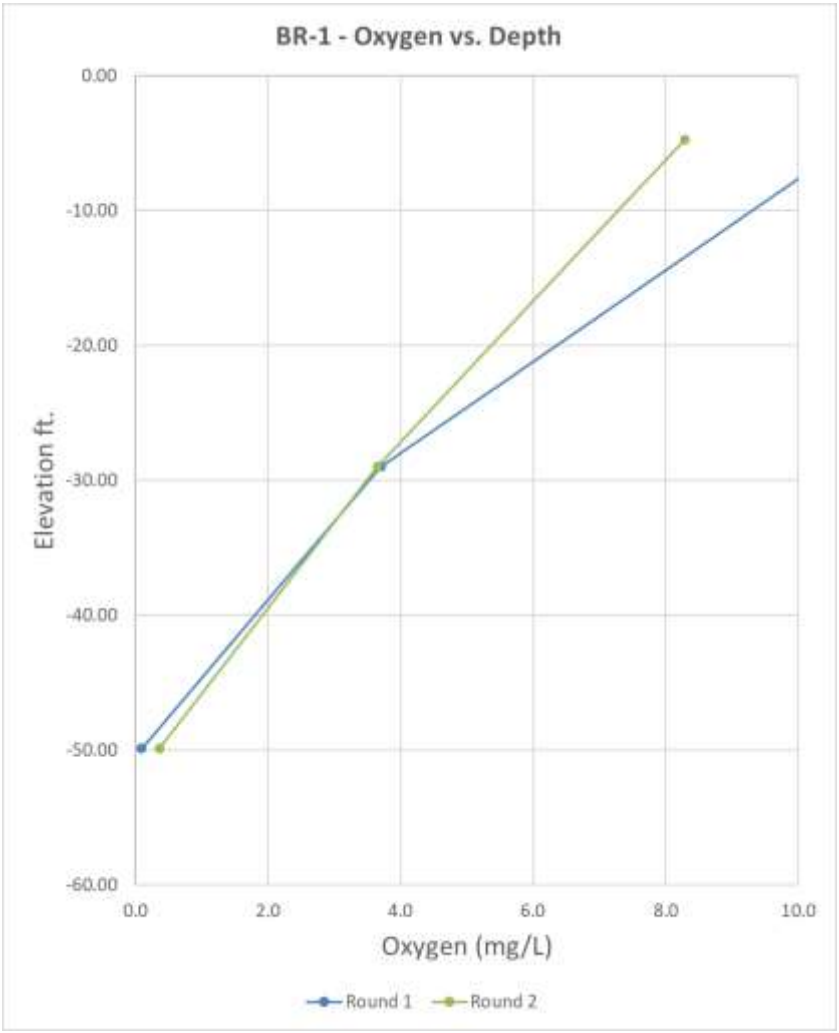

DU-5 - Nitrate vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2

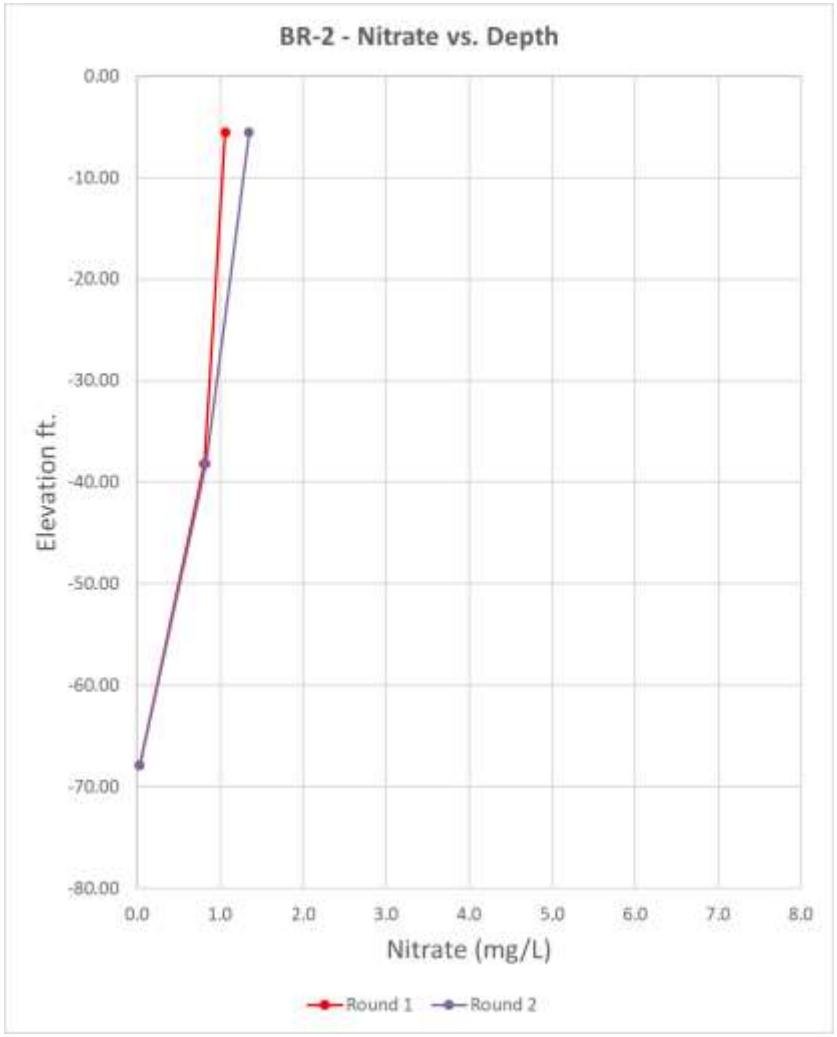

DU-5 - Oxygen vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
Elevation ft.
0.0
2.0
4.0
6.0
8.0
10.0
Oxygen (mg/L)
Round 1
Round 2

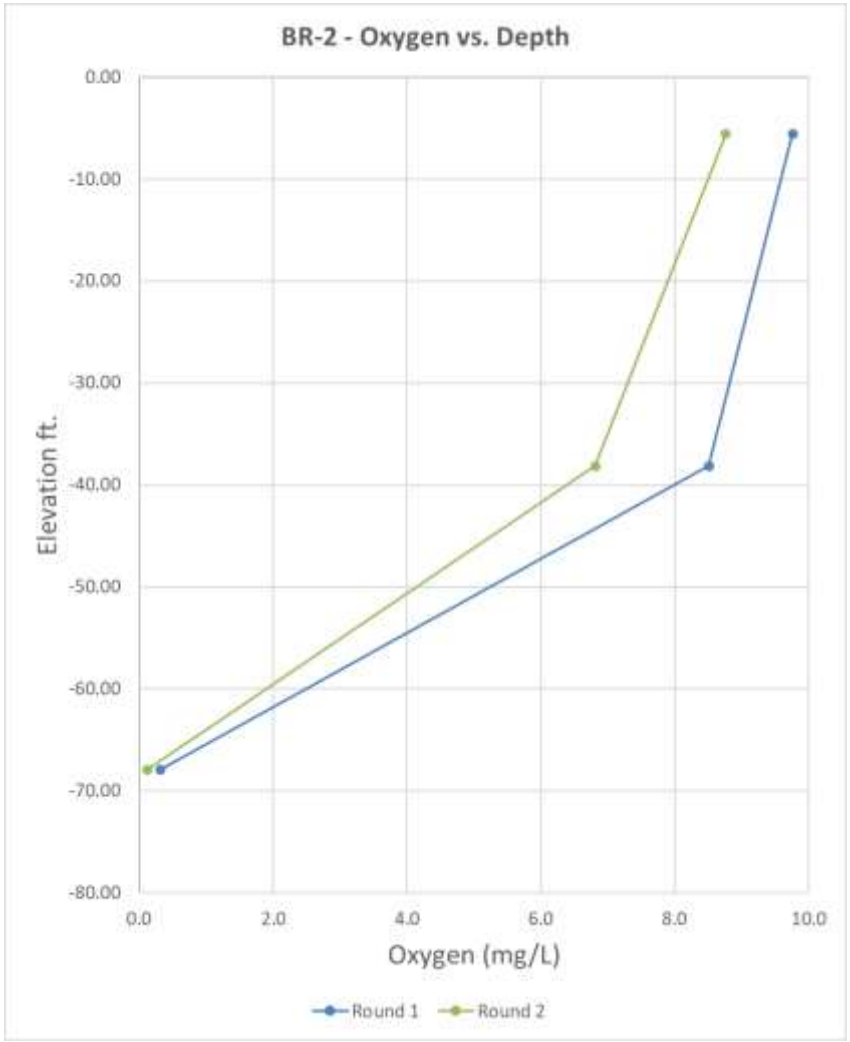

DU-6 - Nitrate vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2

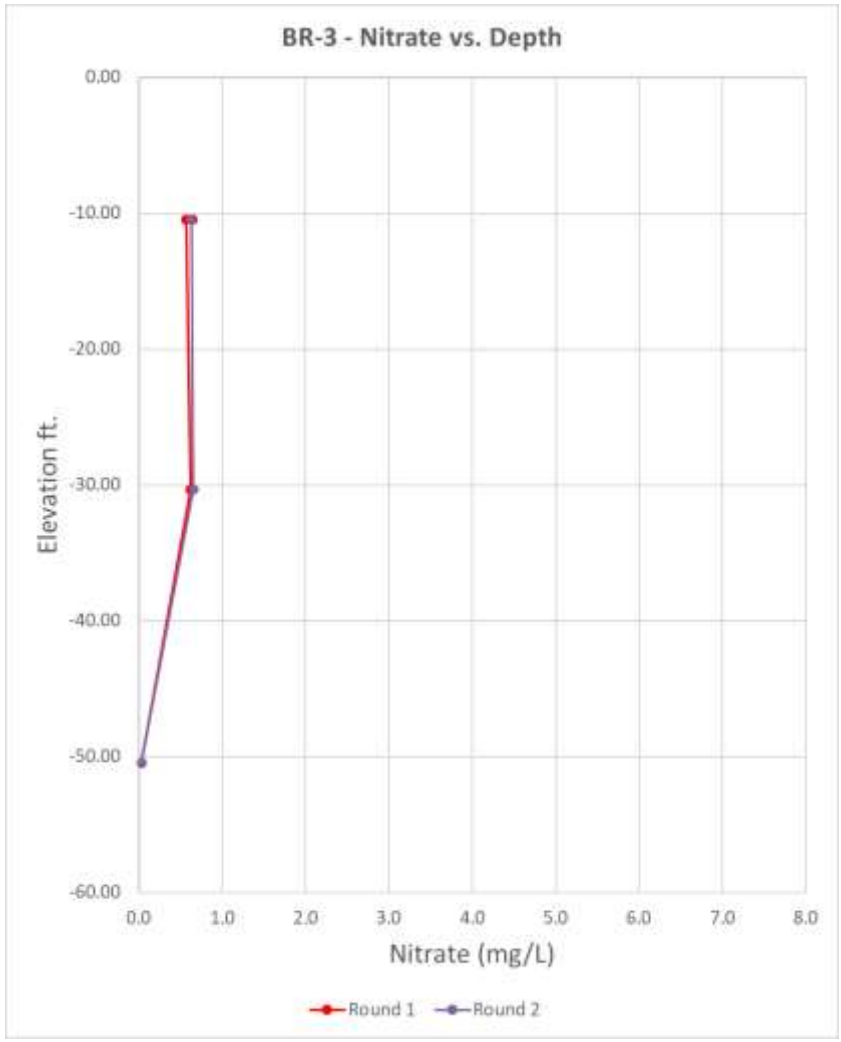

DU-6 - Oxygen vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
Elevation ft.
0.0
2.0
4.0
6.0
8.0
10.0
Oxygen (mg/L)
Round 1
Round 2

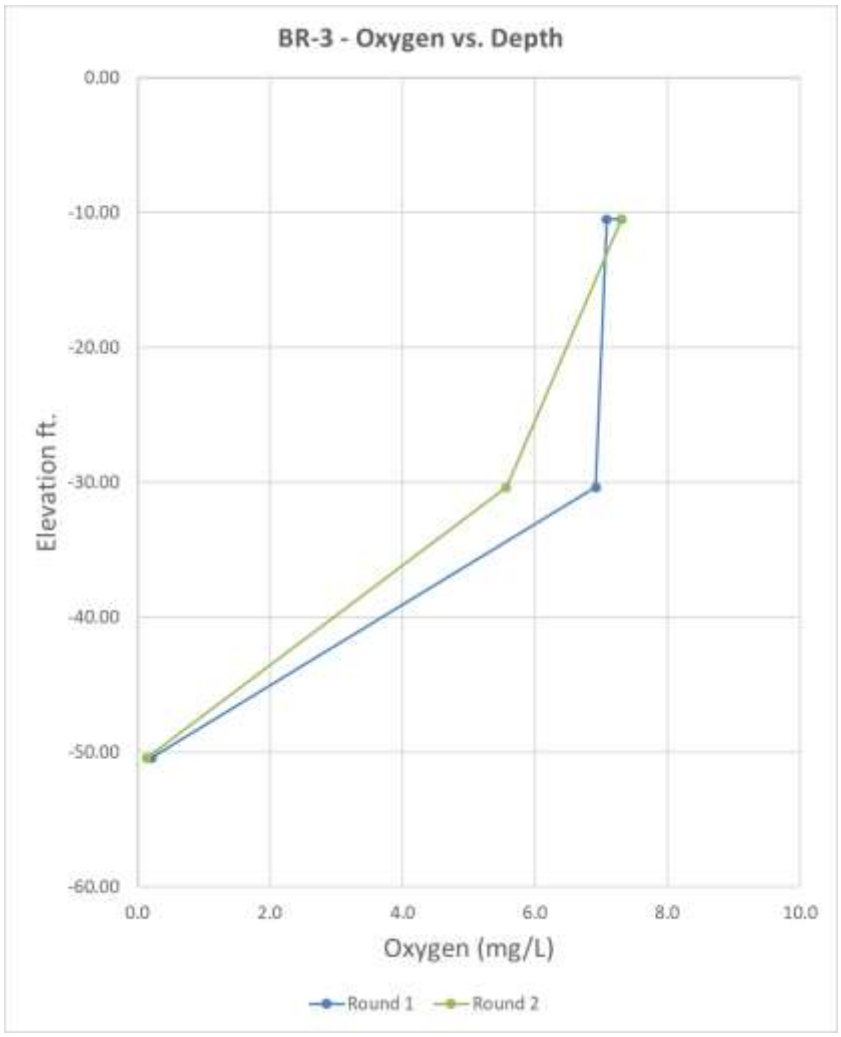

BR-1 - Nitrate vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2

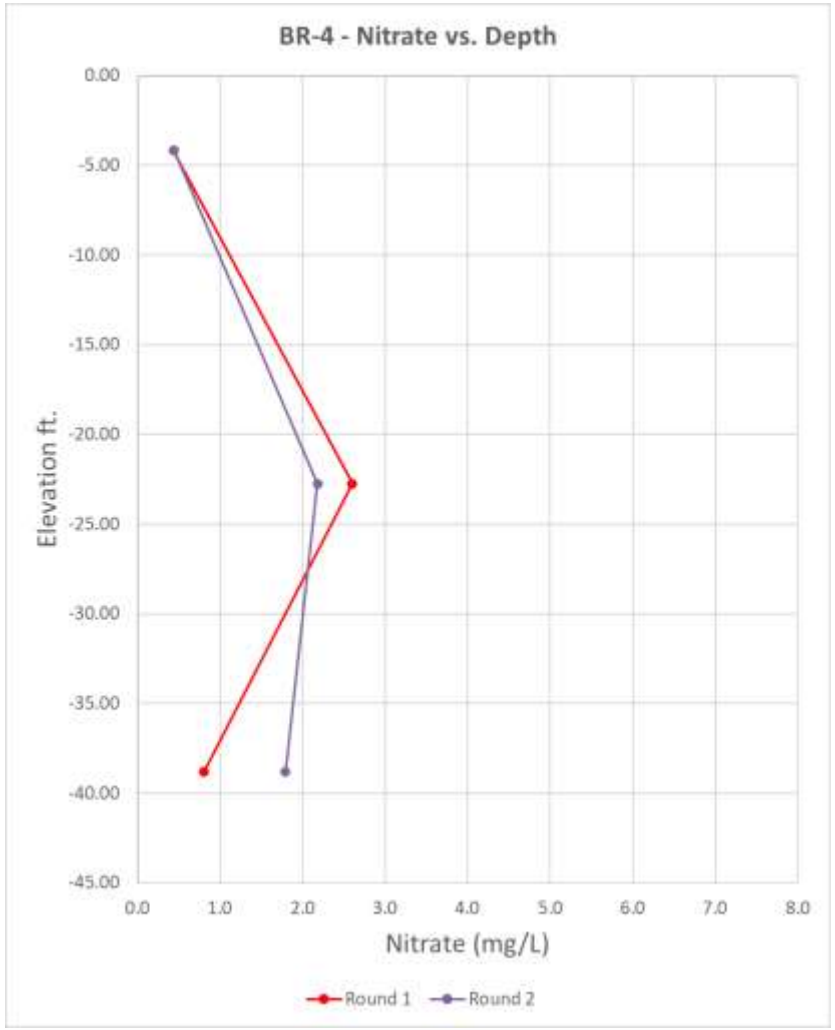

BR-1 - Oxygen vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
Elevation ft.
0.0
2.0
4.0
6.0
8.0
10.0
Oxygen (mg/L)
Round 1
Round 2

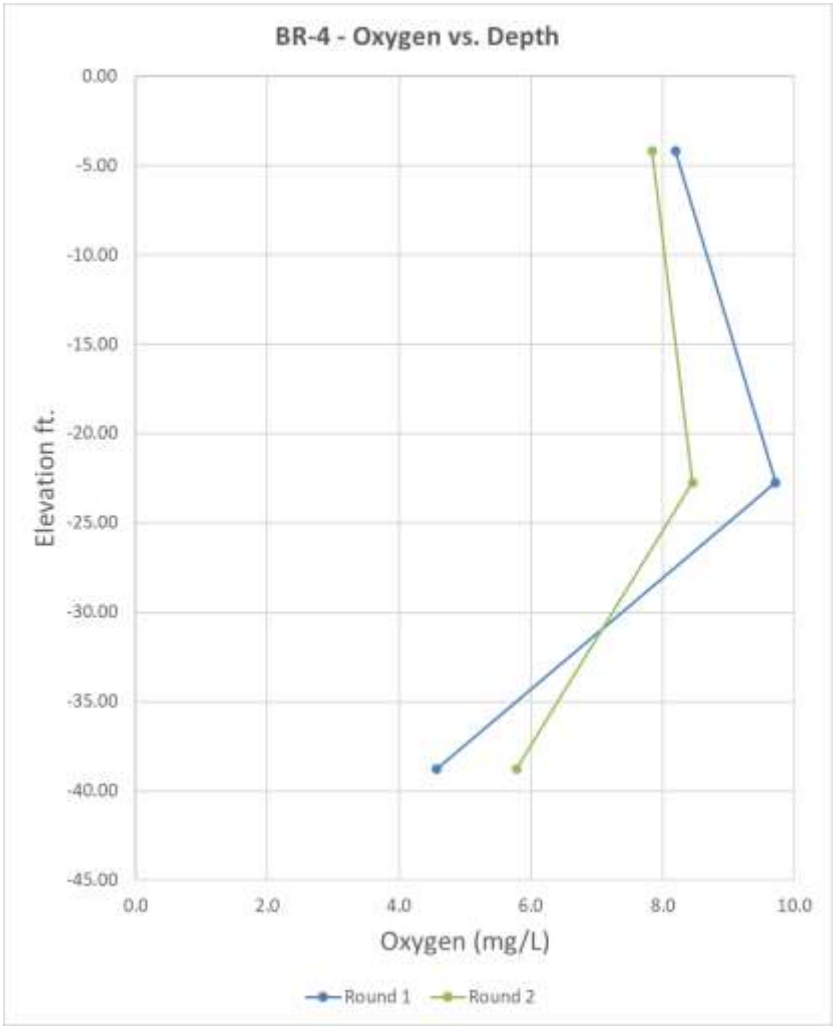

BR-2 - Nitrate vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2

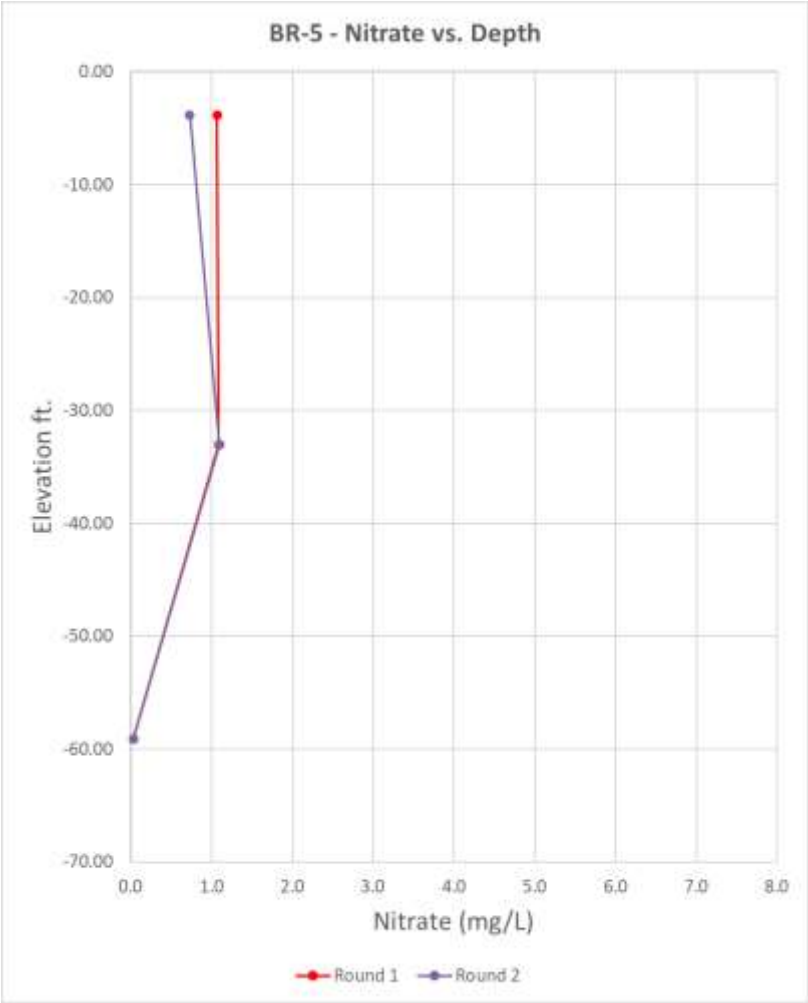

BR-2 - Oxygen vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
Elevation ft.
0.0
2.0
4.0
6.0
8.0
10.0
Oxygen (mg/L)
Round 1
Round 2

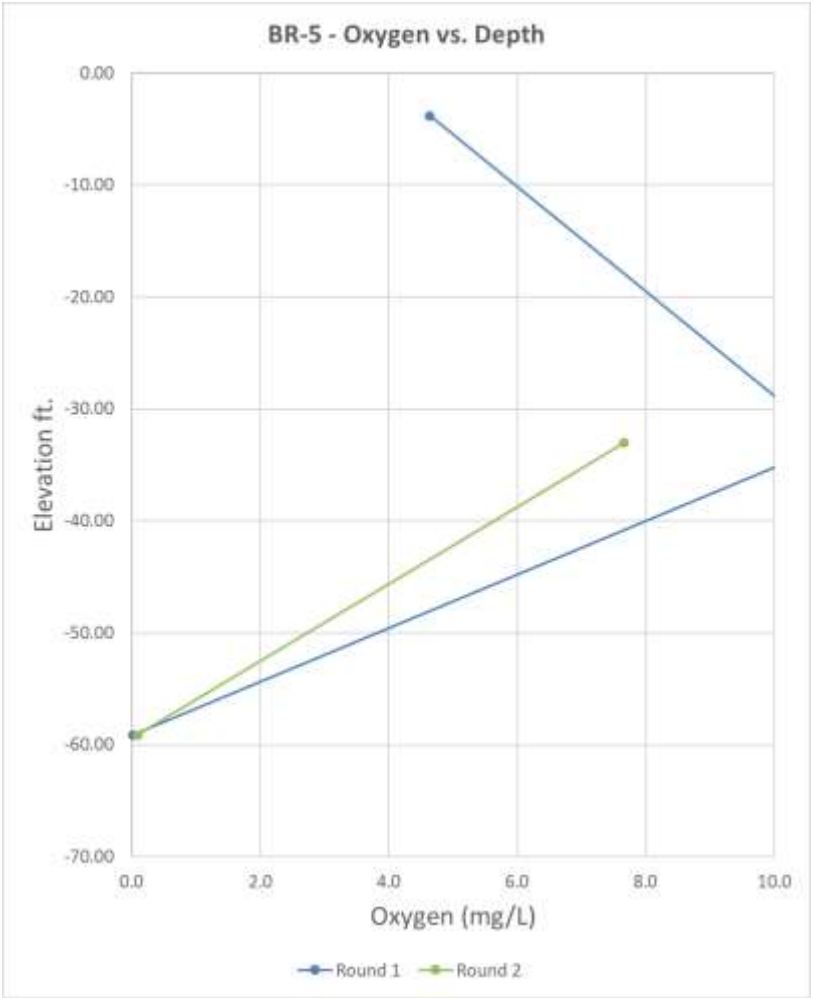

BR-3 - Nitrate vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2

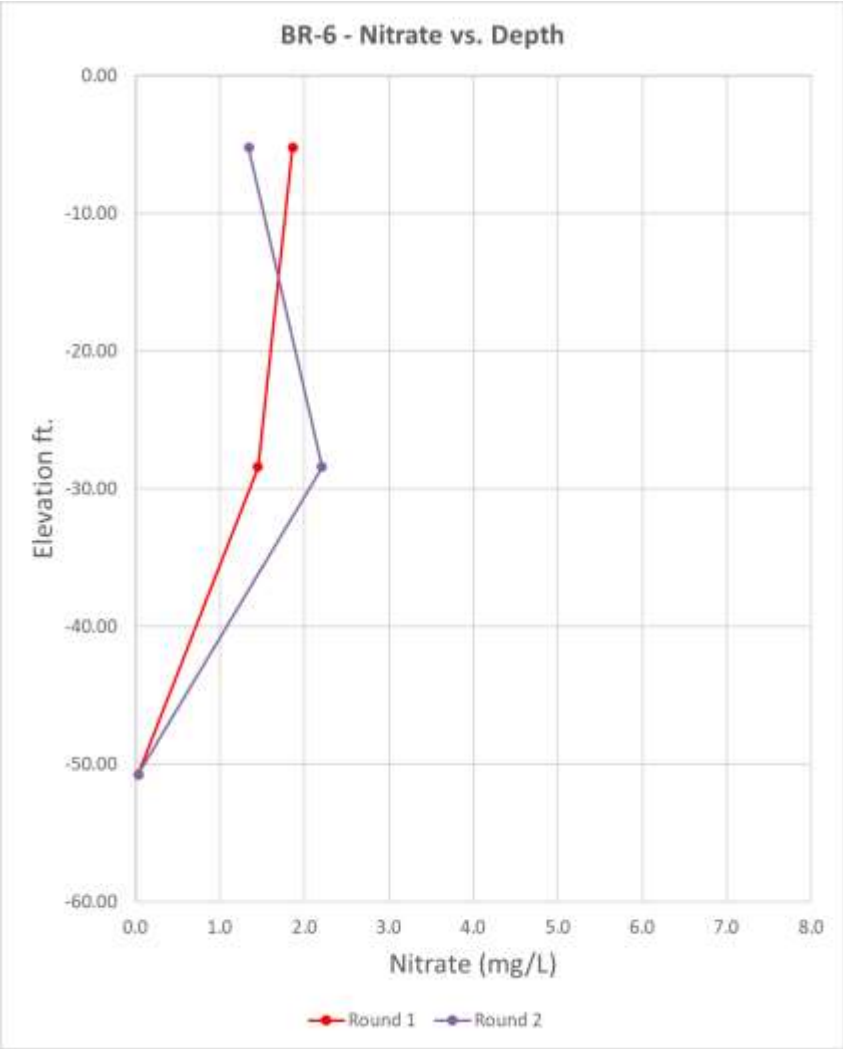

BR-3 - Oxygen vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
Elevation ft.
0.0
2.0
4.0
6.0
8.0
10.0
Oxygen (mg/L)
Round 1
Round 2

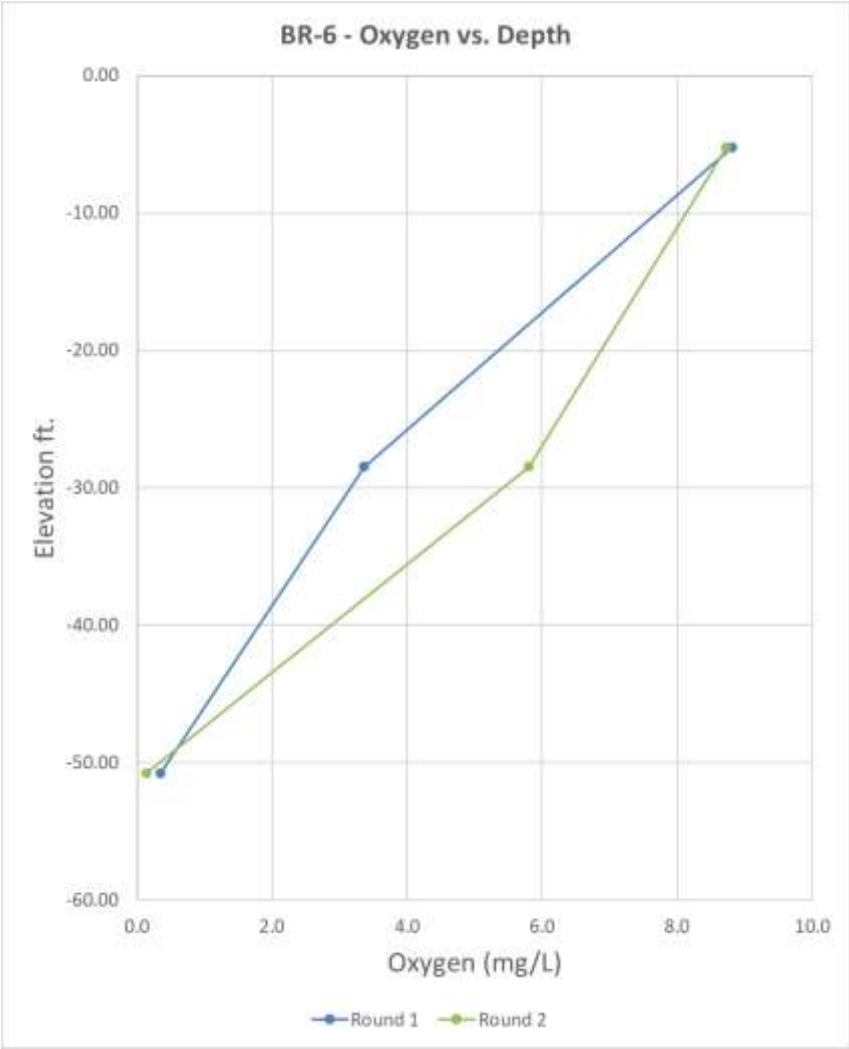

BR-4 - Nitrate vs. Depth
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
-35.00
-40.00
-45.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2

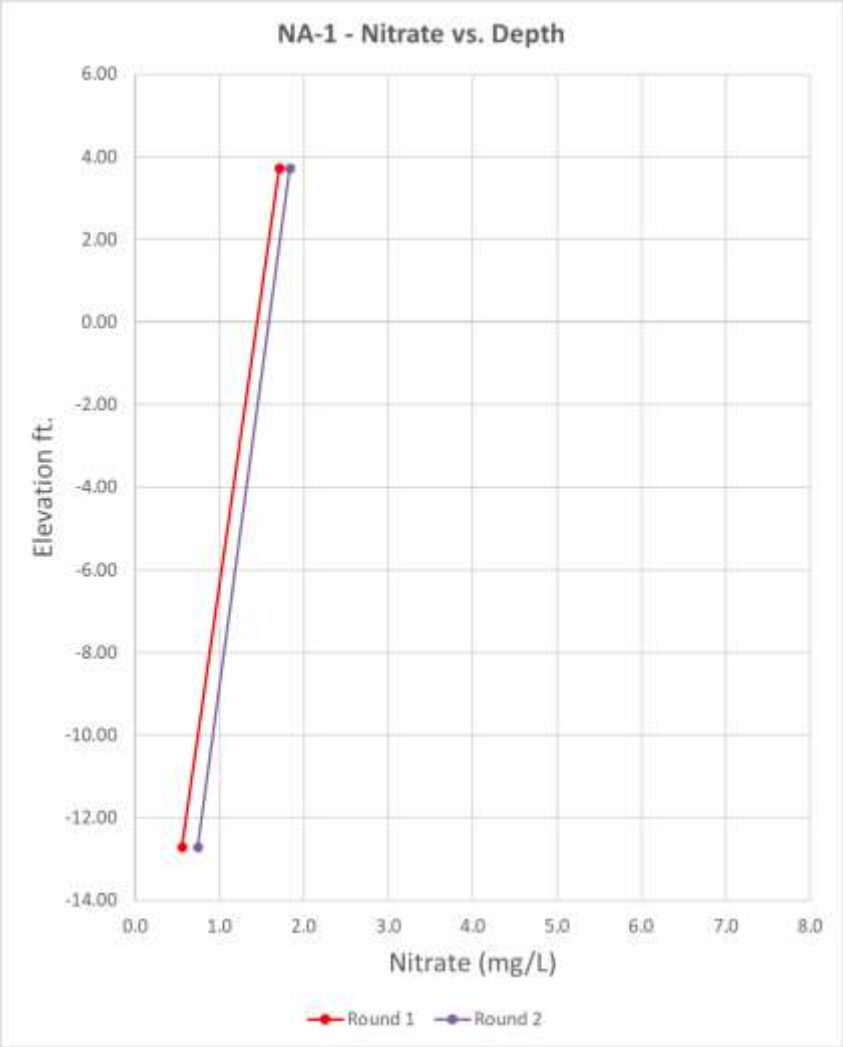

BR-4 - Oxygen vs. Depth
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
-35.00
-40.00
-45.00
Elevation ft.
0.0
2.0
4.0
6.0
8.0
10.0
Oxygen (mg/L)
Round 1
Round 2

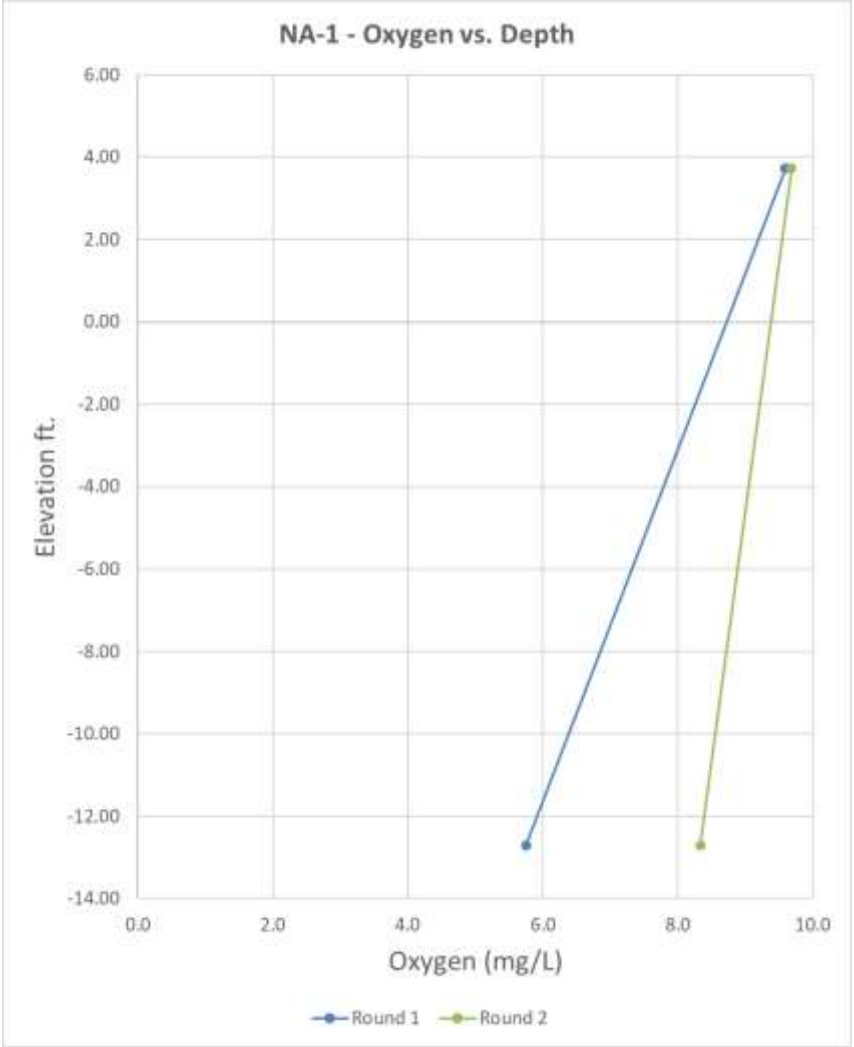

BR-5 - Nitrate vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2

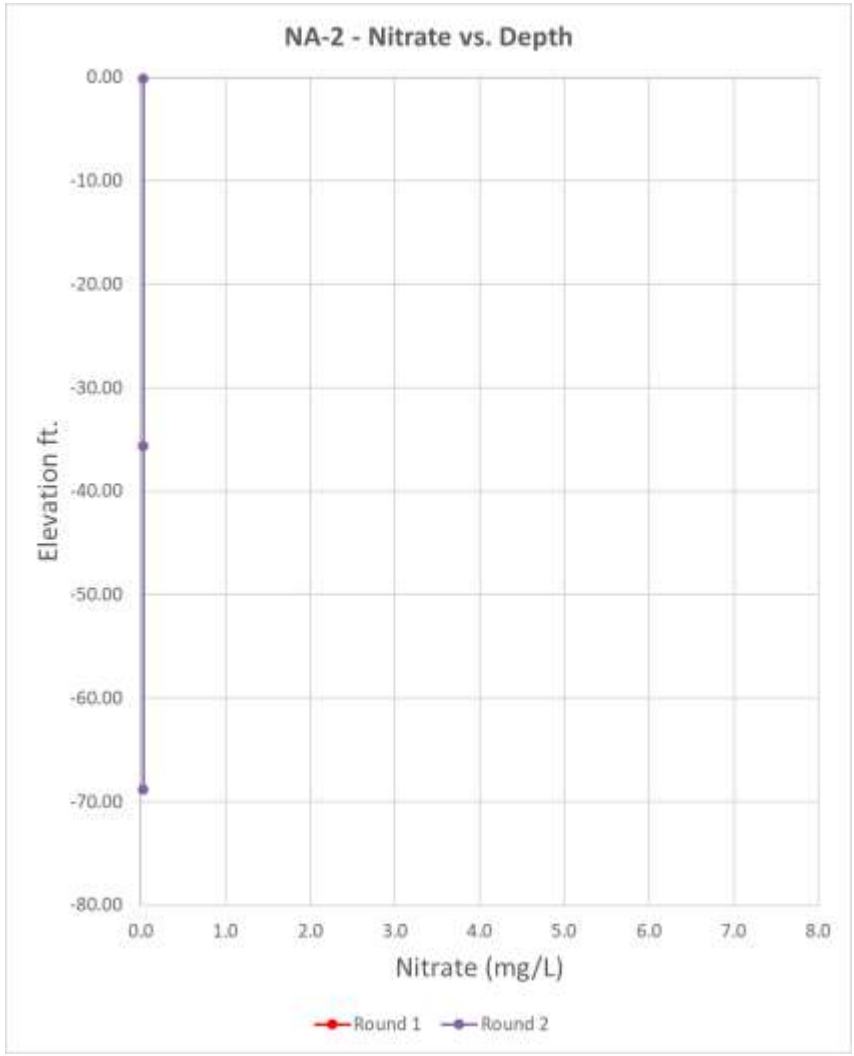

BR-5 - Oxygen vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
Elevation ft.
0.0
2.0
4.0
6.0
8.0
10.0
Oxygen (mg/L)
Round 1
Round 2

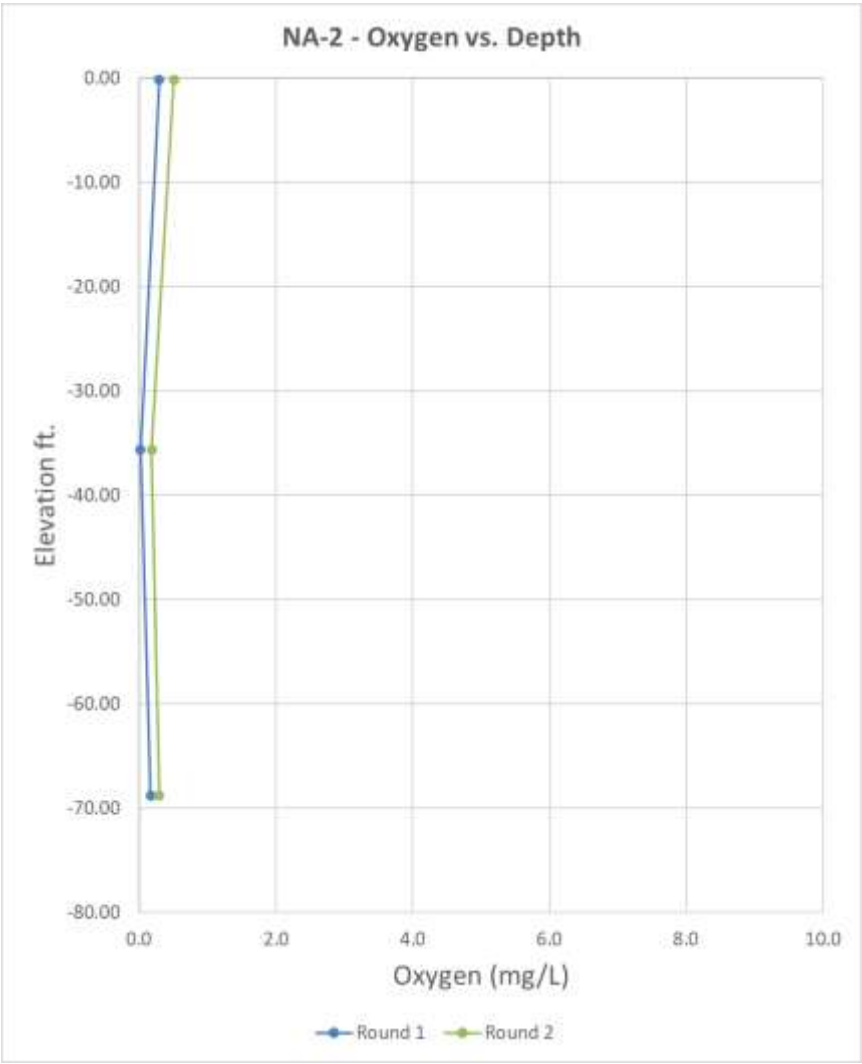

BR-6 - Nitrate vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2

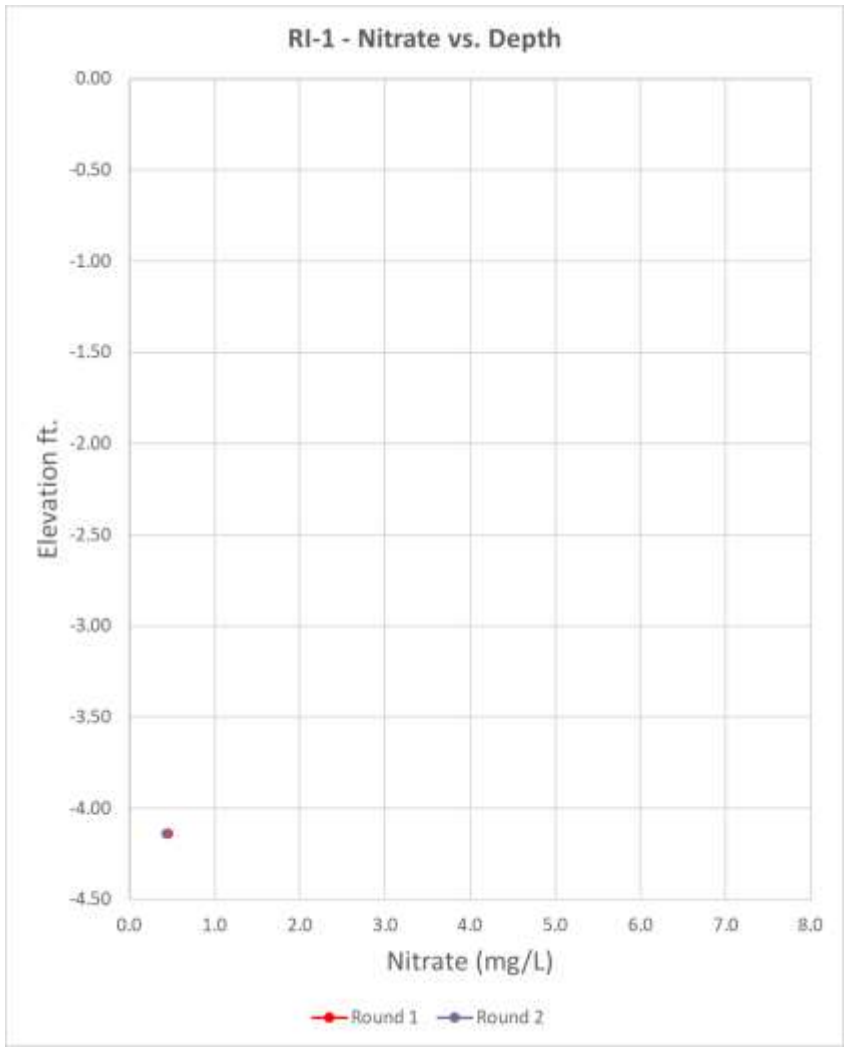

BR-6 - Oxygen vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
Elevation ft.
0.0
2.0
4.0
6.0
8.0
10.0
Oxygen (mg/L)
Round 1
Round 2

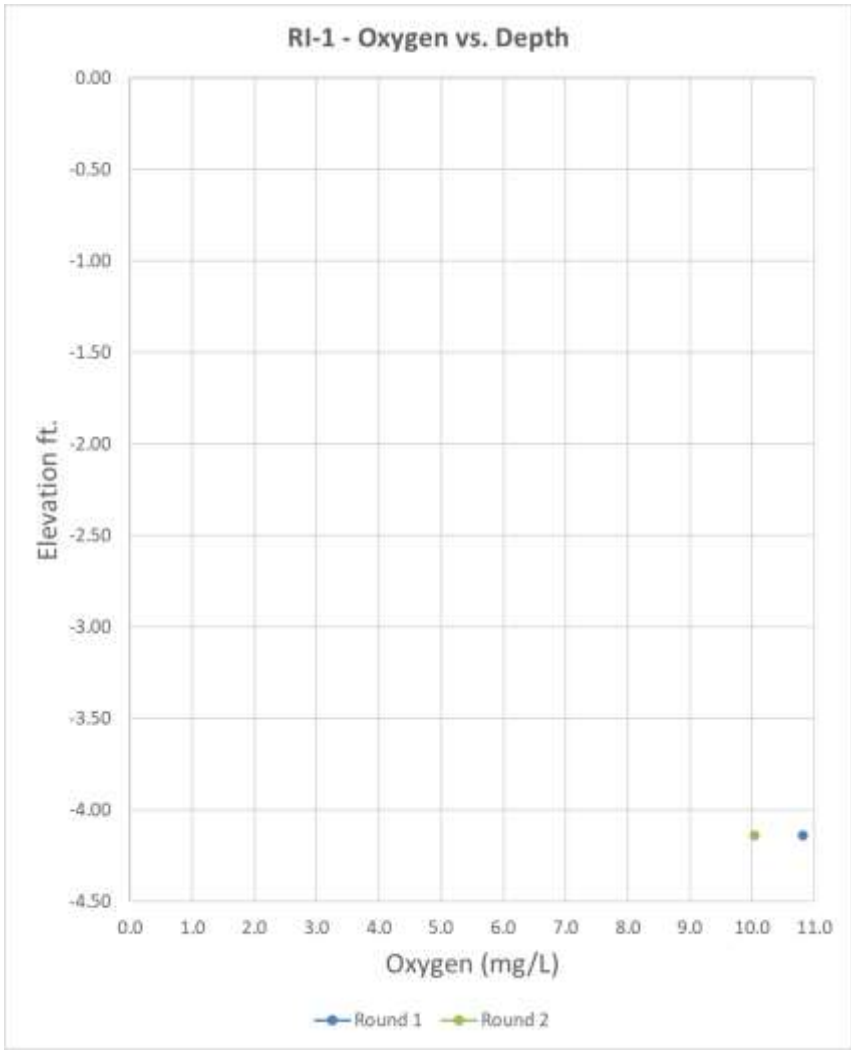

NA-1 - Nitrate vs. Depth
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
-14.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2

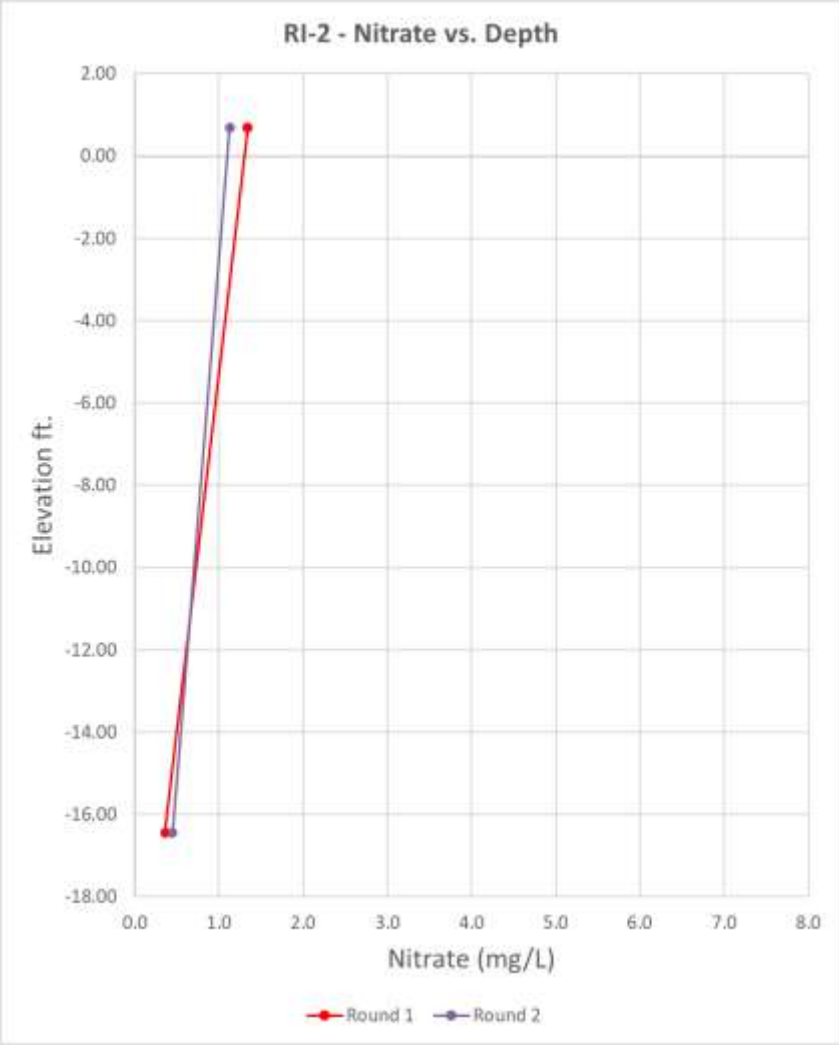

NA-1 - Oxygen vs. Depth
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
-14.00
Elevation ft.
0.0
2.0
4.0
6.0
8.0
10.0
Oxygen (mg/L)
Round 1
Round 2

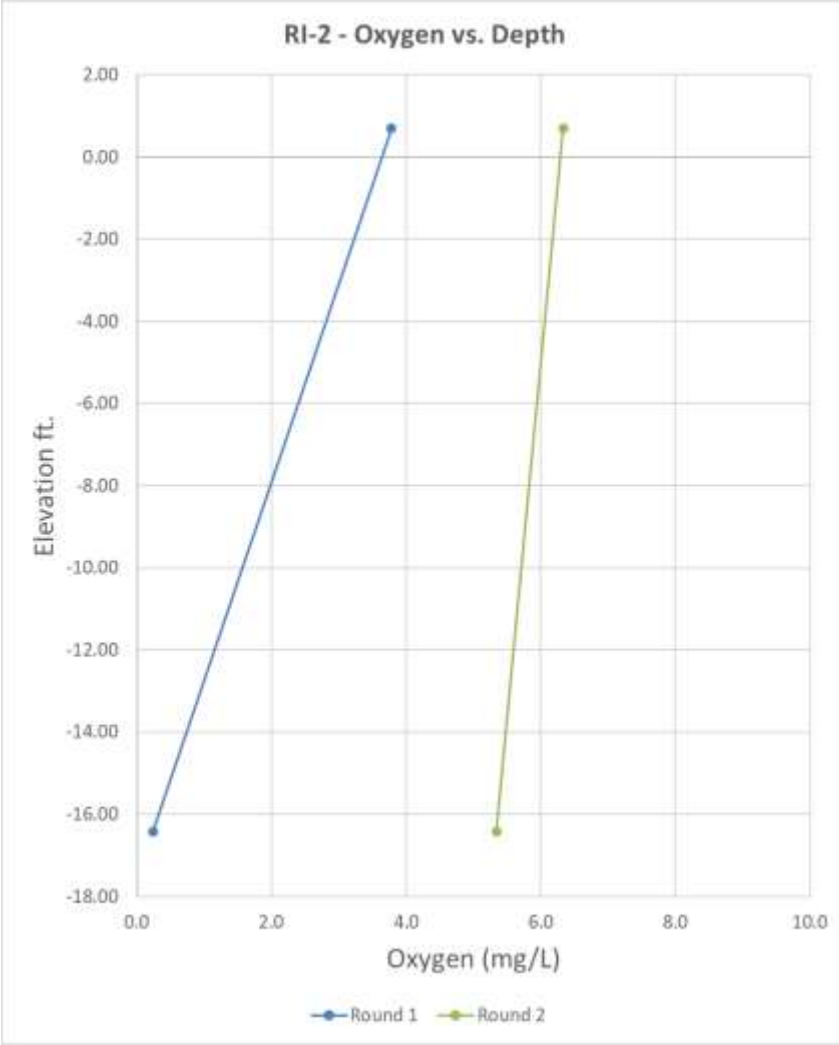

NA-2 - Nitrate vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2

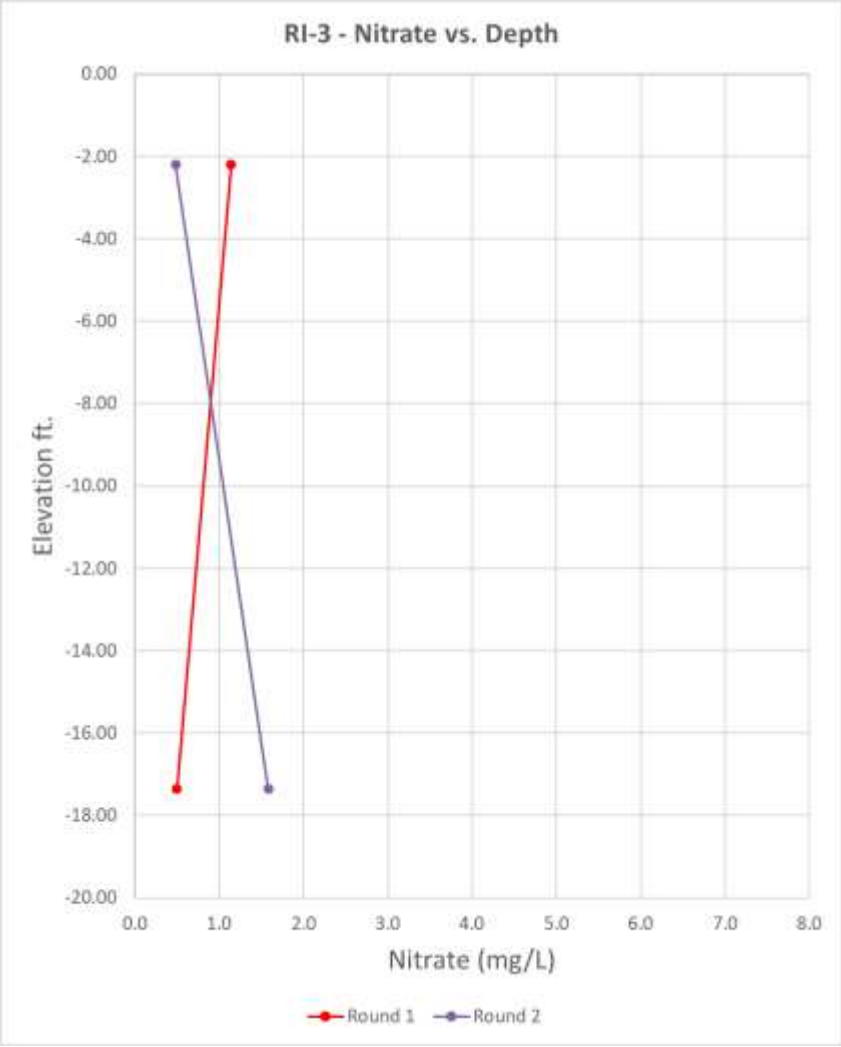

NA-2 - Oxygen vs. Depth
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
Elevation ft.
0.0
2.0
4.0
6.0
8.0
10.0
Oxygen (mg/L)
Round 1
Round 2

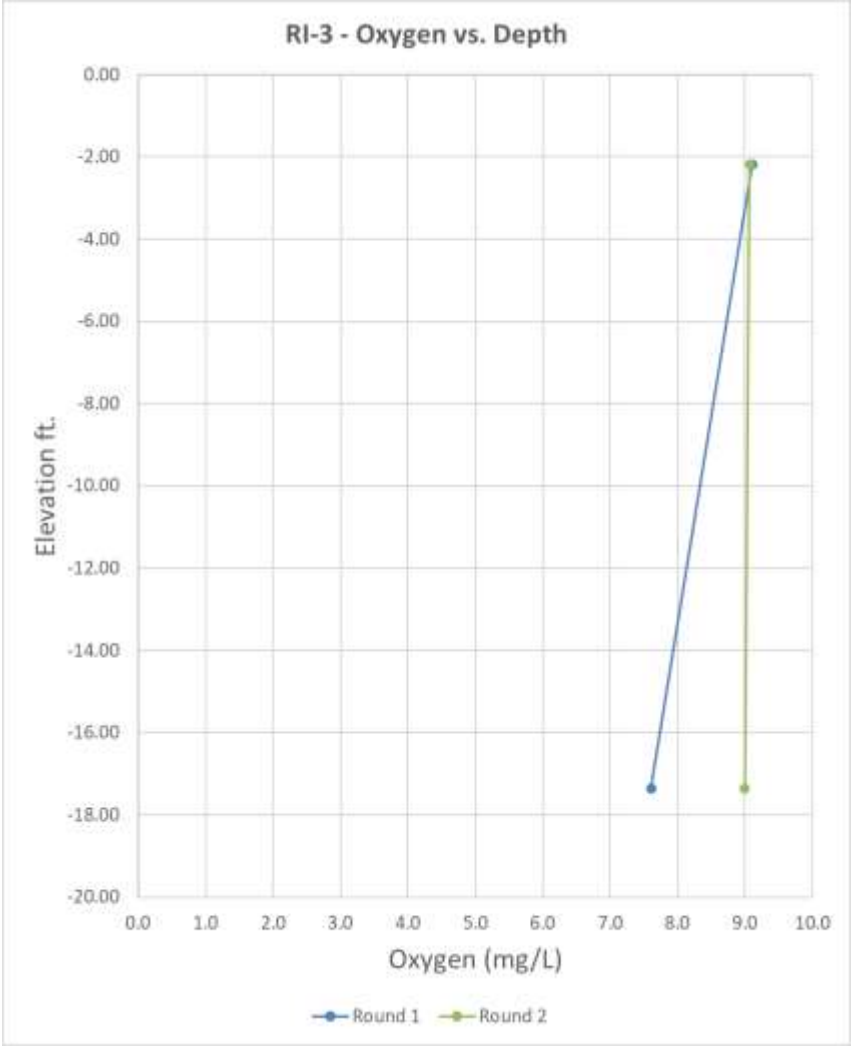

RI-1 - Nitrate vs. Depth
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
-3.50
-4.00
-4.50
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2


RI-1 - Oxygen vs. Depth
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
-3.50
-4.00
-4.50
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
Oxygen (mg/L)
Round 1
Round 2


RI-2 - Nitrate vs. Depth
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
-14.00
-16.00
-18.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2


RI-2 - Oxygen vs. Depth
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
-14.00
-16.00
-18.00
Elevation ft.
0.0
2.0
4.0
6.0
8.0
10.0
Oxygen (mg/L)
Round 1
Round 2


RI-3 - Nitrate vs. Depth
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
-14.00
-16.00
-18.00
-20.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Nitrate (mg/L)
Round 1
Round 2


RI-3 - Oxygen vs. Depth
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
-14.00
-16.00
-18.00
-20.00
Elevation ft.
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Oxygen (mg/L)
Round 1
Round 2

Appendix E: Laboratory Reports

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CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 21K0110

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.



Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 3:08 pm, Nov 09, 2021

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0110

SAMPLE RECEIPT

The following samples were received on November 02, 2021 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

The cooler temperature was not within the acceptance limit of <6°C, however, samples were delivered on ice and therefore meet regulatory criteria.

Lab Number	Sample Name	Matrix	Analysis
21K0110-01	MW-B12C	Ground Water	353.2, 4500N, 5310B
21K0110-02	MW-NA-1-92	Ground Water	200.7, 353.2, 4500N
21K0110-03	MW-B1020B	Ground Water	353.2, 4500N, 5310B
21K0110-04	MW-BX1B	Ground Water	353.2, 4500N, 5310B
21K0110-05	MW-RI-1-105	Ground Water	200.7, 353.2, 4500N
21K0110-06	MW-RI-3-90	Ground Water	200.7, 353.2, 4500N

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0110

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0110

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B12C
Date Sampled: 11/02/21 13:05
Percent Solids: N/A

ESS Laboratory Work Order: 21K0110
ESS Laboratory Sample ID: 21K0110-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**2.41** (0.500)		5310B		1	CCP	11/03/21 2:32	mg/L	[CALC]
Nitrate as N	**0.512** (0.0300)		353.2		1	JLK	11/03/21 18:39	mg/L	[CALC]
Nitrite as N	**0.011** (0.010)		353.2		1	JLK	11/03/21 16:56	mg/L	DK10337
Total Nitrogen	**0.929** (0.200)		4500N		1	JLK	11/08/21 16:59	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-NA-1-92
Date Sampled: 11/02/21 15:25
Percent Solids: N/A

ESS Laboratory Work Order: 21K0110
ESS Laboratory Sample ID: 21K0110-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.117** (0.100)		200.7		1	KJK	11/03/21 18:05	10	10	DK10346
Manganese	**0.207** (0.020)		200.7		1	KJK	11/03/21 18:05	10	10	DK10346

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-NA-1-92
Date Sampled: 11/02/21 15:25
Percent Solids: N/A

ESS Laboratory Work Order: 21K0110
ESS Laboratory Sample ID: 21K0110-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**0.552** (0.0300)		353.2		1	JLK	11/03/21 18:40	mg/L	[CALC]
Nitrite as N	**0.017** (0.010)		353.2		1	JLK	11/03/21 16:57	mg/L	DK10337
Total Nitrogen	**0.774** (0.200)		4500N		1	JLK	11/08/21 16:59	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B1020B
Date Sampled: 11/02/21 12:35
Percent Solids: N/A

ESS Laboratory Work Order: 21K0110
ESS Laboratory Sample ID: 21K0110-03
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**5.12** (0.500)		5310B		1	CCP	11/03/21 2:44	mg/L	[CALC]
Nitrate as N	ND (0.0300)		353.2		1	JLK	11/03/21 18:41	mg/L	[CALC]
Nitrite as N	**0.060** (0.010)		353.2		1	JLK	11/03/21 16:58	mg/L	DK10337
Total Nitrogen	**0.814** (0.200)		4500N		1	JLK	11/08/21 17:00	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BX1B
Date Sampled: 11/02/21 13:35
Percent Solids: N/A

ESS Laboratory Work Order: 21K0110
ESS Laboratory Sample ID: 21K0110-04
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**55.1** (2.00)		5310B		4	CCP	11/03/21 13:51	mg/L	[CALC]
Nitrate as N	**0.222** (0.0300)		353.2		1	JLK	11/03/21 18:42	mg/L	[CALC]
Nitrite as N	**0.088** (0.010)		353.2		1	JLK	11/03/21 16:59	mg/L	DK10337
Total Nitrogen	**0.906** (0.200)		4500N		1	JLK	11/08/21 17:01	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-RI-1-105
Date Sampled: 11/02/21 15:15
Percent Solids: N/A

ESS Laboratory Work Order: 21K0110
ESS Laboratory Sample ID: 21K0110-05
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	11/03/21 18:20	10	10	DK10346
Manganese	**0.130** (0.020)		200.7		1	KJK	11/03/21 18:20	10	10	DK10346

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-RI-1-105
Date Sampled: 11/02/21 15:15
Percent Solids: N/A

ESS Laboratory Work Order: 21K0110
ESS Laboratory Sample ID: 21K0110-05
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**0.449** (0.0300)		353.2		1	JLK	11/03/21 18:48	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	11/03/21 17:05	mg/L	DK10337
Total Nitrogen	**0.449** (0.200)		4500N		1	JLK	11/08/21 17:02	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-RI-3-90
Date Sampled: 11/02/21 16:40
Percent Solids: N/A

ESS Laboratory Work Order: 21K0110
ESS Laboratory Sample ID: 21K0110-06
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**2.19** (0.100)		200.7		1	KJK	11/03/21 18:22	10	10	DK10346
Manganese	**0.443** (0.020)		200.7		1	KJK	11/03/21 18:22	10	10	DK10346

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-RI-3-90
Date Sampled: 11/02/21 16:40
Percent Solids: N/A

ESS Laboratory Work Order: 21K0110
ESS Laboratory Sample ID: 21K0110-06
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**0.494** (0.0300)		353.2		1	JLK	11/03/21 18:49	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	11/03/21 17:06	mg/L	DK10337
Total Nitrogen	**0.494** (0.200)		4500N		1	JLK	11/08/21 17:08	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0110

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DK10346 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.57		mg/L	2.500		103	80-120			
Manganese	0.523		mg/L	0.5000		105	80-120			
Classical Chemistry										
Batch DK10243 - General Preparation										
Blank										
Dissolved Organic Carbon (1)	ND	0.500	mg/L							
Dissolved Organic Carbon (2)	ND	0.500	mg/L							
LCS										
Dissolved Organic Carbon (1)	4.71	0.500	mg/L	5.000		94	80-120			
Dissolved Organic Carbon (2)	4.79	0.500	mg/L	5.000		96	80-120			
LCS Dup										
Dissolved Organic Carbon (1)	4.80	0.500	mg/L	5.000		96	80-120	2	20	
Dissolved Organic Carbon (2)	4.83	0.500	mg/L	5.000		97	80-120	0.8	20	
Batch DK10337 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.246		mg/L	0.2497		98	90-110			
Nitrite as N	0.246		mg/L	0.2497		98	90-110			
Batch DK10339 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.544		mg/L	0.5000		109	90-110			
Nitrate/Nitrite as N	0.544		mg/L	0.5000		109	90-110			
Batch DK10452 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	10.7	2.00	mg/L	10.30		104	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0110

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0110

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ~~ESS Courier~~ Client mm 11/2/21

ESS Project ID: 21K0110
Date Received: 11/2/2021
Project Due Date: 11/9/2021
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 8.3 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** Yes / No / NA
10. Were any analyses received outside of hold time? Yes / No

11. Any Subcontracting needed? Yes / No
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / No
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA

13. Are the samples properly preserved? Yes / No
    a. If metals preserved upon receipt: Date: Time: By:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

14. Was there a need to contact Project Manager? Yes / No
    a. Was there a need to contact the client? Yes / No
    Who was contacted? Date: Time: By:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	225277	Yes	N/A	Yes	1L Poly	H2SO4	
1	225283	Yes	N/A	Yes	250 mL Poly	NP	
1	225289	Yes	N/A	Yes	250 mL Amber	NP	
2	225278	Yes	N/A	Yes	1L Poly	H2SO4	
2	225284	Yes	N/A	Yes	250 mL Poly	NP	
2	225292	Yes	N/A	Yes	250 mL Poly	NP	
3	225279	Yes	N/A	Yes	1L Poly	H2SO4	
3	225285	Yes	N/A	Yes	250 mL Poly	NP	
3	225290	Yes	N/A	Yes	250 mL Amber	NP	
4	225280	Yes	N/A	Yes	1L Poly	H2SO4	
4	225286	Yes	N/A	Yes	250 mL Poly	NP	
4	225291	Yes	N/A	Yes	250 mL Amber	NP	
5	225281	Yes	N/A	Yes	1L Poly	H2SO4	
5	225287	Yes	N/A	Yes	250 mL Poly	NP	
5	225293	Yes	N/A	Yes	250 mL Poly	NP	
6	225282	Yes	N/A	Yes	1L Poly	H2SO4	

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

ESS Project ID: 21K0110
Date Received: 11/2/2021

6	225288	Yes	N/A	Yes	250 mL Poly	NP
6	225294	Yes	N/A	Yes	250 mL Poly	NP

2nd Review

Were all containers scanned into storage/lab? Initials TD

Are barcode labels on correct containers? Yes / No

Are all Flashpoint stickers attached/container ID # circled? Yes / No / NA

Are all Hex Chrome stickers attached? Yes / No / NA

Are all QC stickers attached? Yes / No / NA

Are VOA stickers attached if bubbles noted? Yes / No / NA

Completed By: Taylor Davis Date & Time: 11/2/21 2005

Reviewed By: [signature] Date & Time: 11/2/21 2031

ESS Laboratory

Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 210110

Turn Time	5 Days
Regulatory State	Massachusetts
Is this project for any of the following?:	○CT RCP ○MA MCP ○RGP
Reporting Limits	
Electonic Deliverables	☐Data Checker ☐Excel ☐Other (Please Specify →)

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB

Julianne Marrion	Address: 250 Apollo Dr		
City: Chelmsford	State: MA	Zip Code: 01824	PO #
Telephone Number: 978-905-2419	FAX Number	Email Address: julianne.marrion@aecom.com	

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: Total Nitrogen	Nitrate, Nitrite	Lab Filter Dissolved Fe, Mn	DOC	Methane
1	11/02/21	1305	Grab	Ground Water	MW-B12C	X	X		X	
2	11/02/21	1525	Grab	Ground Water	MW-NA-1-92	X	X	X		
3	11/02/21	1235	Grab	Ground Water	MW-B1020B	X	X		X	
4	11/02/21	1335	Grab	Ground Water	MW-BX1B	X	X		X	
5	11/02/21	1515	Grab	Ground Water	MW-RI-1-105	X	X	X		
6	11/02/21	1640	Grab	Ground Water	MW-RI-3-90	X	X	X		
			Grab	Ground Water						
			Grab	Ground Water						
			Grab	Ground Water						
			Grab	Ground Water						

Container Type:	AC-Air Cassette	AG-Amber Glass	B-BOD Bottle	C-Cubitainer	J-Jar	O-Other	P-Poly	S-Sterile	V-Vial	P	P	P	AG	V
Container Volume:	1-100 mL	2-2.5 gal	3-250 mL	4-300 mL	5-500 mL	6-1L	7-VOA	8-2 oz	9-4 oz	10-8 oz	11-Other*	6	3	3	3	7
Preservation Code:	1-Non Preserved	2-HCl	3-H2SO4	4-HNO3	5-NaOH	6-Methanol	7-Na2S2O3	8-ZnAce, NaOH	9-NH4Cl	10-DI H2O	11-Other*	3	1	1	1	2
											Number of Containers per Sample:	1	1	1	1	2

Laboratory Use Only

Cooler Present: ✓ ○Drop Off
Seals Intact: ○Pickup
Cooler Temperature: 8.3 °C Ice

Sampled by : Briley Barra AECOM Briley Barra

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
Briley Barra 11/02/21 1921	11/2/21 1921		
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 21K0192

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 5:20 pm, Nov 10, 2021

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0192

SAMPLE RECEIPT

The following samples were received on November 03, 2021 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
21K0192-01	MW-RI-2-58	Ground Water	200.7, 353.2, 4500N
21K0192-02	MW-NA-2-88	Ground Water	200.7, 353.2, 4500N
21K0192-03	MW-BR-2-96	Ground Water	200.7, 353.2, 4500N
21K0192-04	MW-BR-1-98	Ground Water	200.7, 353.2, 4500N
21K0192-05	MW-BR-3-100	Ground Water	200.7, 353.2, 4500N
21K0192-06	MW-BR-3-60	Ground Water	200.7, 353.2, 4500N
21K0192-07	MW-BR-5-90	Ground Water	200.7, 353.2, 4500N
21K0192-08	MW-BR-6-100	Ground Water	200.7, 353.2, 4500N
21K0192-09	MW-BR-4-100	Ground Water	200.7, 353.2, 4500N
21K0192-10	MW-B1050B	Ground Water	353.2, 4500N, 5310B, RSK175
21K0192-11	MW-BX2C	Ground Water	353.2, 4500N, 5310B

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0192

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0192

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-RI-2-58
Date Sampled: 11/03/21 10:00
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	11/05/21 21:35	10	10	DK10535
Manganese	**1.23** (0.020)		200.7		1	KJK	11/05/21 21:35	10	10	DK10535

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-RI-2-58
Date Sampled: 11/03/21 10:00
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**0.360** (0.0300)		353.2		1	JLK	11/04/21 20:29	mg/L	[CALC]
Nitrite as N	**0.366** (0.010)		353.2		1	JLK	11/04/21 19:28	mg/L	DK10448
Total Nitrogen	**1.42** (0.200)		4500N		1	JLK	11/08/21 17:09	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-NA-2-88
Date Sampled: 11/03/21 10:40
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.695** (0.100)		200.7		1	KJK	11/05/21 21:50	10	10	DK10535
Manganese	**0.445** (0.020)		200.7		1	KJK	11/05/21 21:50	10	10	DK10535

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-NA-2-88
Date Sampled: 11/03/21 10:40
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	ND (0.0300)		353.2		1	JLK	11/04/21 20:30	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	11/04/21 19:29	mg/L	DK10448
Total Nitrogen	**0.330** (0.200)		4500N		1	JLK	11/08/21 17:10	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BR-2-96
Date Sampled: 11/03/21 11:45
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-03
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**3.28** (0.100)		200.7		1	KJK	11/05/21 21:52	10	10	DK10535
Manganese	**0.368** (0.020)		200.7		1	KJK	11/05/21 21:52	10	10	DK10535

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BR-2-96
Date Sampled: 11/03/21 11:45
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-03
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	ND (0.0300)		353.2		1	JLK	11/04/21 20:31	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	11/04/21 19:30	mg/L	DK10448
Total Nitrogen	**1.09** (0.200)		4500N		1	JLK	11/08/21 17:11	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BR-1-98
Date Sampled: 11/03/21 13:30
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-04
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.701** (0.100)		200.7		1	KJK	11/05/21 21:54	10	10	DK10535
Manganese	**0.506** (0.020)		200.7		1	KJK	11/05/21 21:54	10	10	DK10535

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BR-1-98
Date Sampled: 11/03/21 13:30
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-04
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**0.162** (0.0300)		353.2		1	JLK	11/04/21 20:32	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	11/04/21 19:31	mg/L	DK10448
Total Nitrogen	ND (0.200)		4500N		1	JLK	11/08/21 17:12	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BR-3-100
Date Sampled: 11/03/21 11:50
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-05
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.904** (0.100)		200.7		1	KJK	11/05/21 21:56	10	10	DK10535
Manganese	**0.349** (0.020)		200.7		1	KJK	11/05/21 21:56	10	10	DK10535

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BR-3-100
Date Sampled: 11/03/21 11:50
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-05
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	ND (0.0300)		353.2		1	JLK	11/04/21 20:33	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	11/04/21 19:32	mg/L	DK10448
Total Nitrogen	**0.325** (0.200)		4500N		1	JLK	11/08/21 17:12	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BR-3-60
Date Sampled: 11/03/21 12:25
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-06
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.151** (0.100)		200.7		1	KJK	11/05/21 21:58	10	10	DK10535
Manganese	**0.043** (0.020)		200.7		1	KJK	11/05/21 21:58	10	10	DK10535

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BR-3-60
Date Sampled: 11/03/21 12:25
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-06
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**0.566** (0.0300)		353.2		1	JLK	11/04/21 21:55	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	11/04/21 21:55	mg/L	DK10448
Total Nitrogen	**0.566** (0.200)		4500N		1	JLK	11/08/21 17:13	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BR-5-90
Date Sampled: 11/03/21 14:20
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-07
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**3.71** (0.100)		200.7		1	KJK	11/05/21 22:00	10	10	DK10535
Manganese	**0.843** (0.020)		200.7		1	KJK	11/05/21 22:00	10	10	DK10535

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BR-5-90
Date Sampled: 11/03/21 14:20
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-07
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	ND (0.0300)		353.2		1	JLK	11/04/21 20:35	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	11/04/21 19:34	mg/L	DK10448
Total Nitrogen	**0.247** (0.200)		4500N		1	JLK	11/08/21 17:14	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BR-6-100
Date Sampled: 11/03/21 14:15
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-08
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**1.37** (0.100)		200.7		1	KJK	11/05/21 22:02	10	10	DK10535
Manganese	**0.401** (0.020)		200.7		1	KJK	11/05/21 22:02	10	10	DK10535

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BR-6-100
Date Sampled: 11/03/21 14:15
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-08
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	ND (0.0300)		353.2		1	JLK	11/04/21 20:41	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	11/04/21 19:39	mg/L	DK10448
Total Nitrogen	**0.412** (0.200)		4500N		1	JLK	11/08/21 17:15	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BR-4-100
Date Sampled: 11/03/21 15:15
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-09
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	11/05/21 22:11	10	10	DK10535
Manganese	**0.332** (0.020)		200.7		1	KJK	11/05/21 22:11	10	10	DK10535

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BR-4-100
Date Sampled: 11/03/21 15:15
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-09
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**0.804** (0.0300)		353.2		1	JLK	11/04/21 20:42	mg/L	[CALC]
Nitrite as N	**0.046** (0.010)		353.2		1	JLK	11/04/21 19:40	mg/L	DK10448
Total Nitrogen	**0.851** (0.200)		4500N		1	JLK	11/08/21 17:16	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B1050B
Date Sampled: 11/03/21 15:35
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-10
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**7.71** (0.500)		5310B		1	CCP	11/04/21 20:16	mg/L	[CALC]
Nitrate as N	ND (0.0300)		353.2		1	JLK	11/04/21 20:43	mg/L	[CALC]
Nitrite as N	**0.062** (0.010)		353.2		1	JLK	11/04/21 19:41	mg/L	DK10448
Total Nitrogen	**1.01** (0.200)		4500N		1	JLK	11/08/21 17:22	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B1050B
Date Sampled: 11/03/21 15:35
Percent Solids: N/A
Initial Volume: 1
Final Volume: 1
Extraction Method: No Prep

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-10
Sample Matrix: Ground Water
Units: ug/L
Analyst: TLW
Prepared: 11/10/21 11:30

All methods used are in accordance with 40 CFR 136.

Methane / Ethane / Ethene by Headspace GCFID (RSK175)

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Sequence	Batch
Ethane	ND (3.0)		RSK175		1	TLW	11/10/21 14:45	D1K0225	DK11029
Ethene	ND (5.0)		RSK175		1	TLW	11/10/21 14:45	D1K0225	DK11029
Methane	**5630** (20.0)		RSK175		10	TLW	11/10/21 14:54	D1K0225	DK11029

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BX2C
Date Sampled: 11/03/21 16:25
Percent Solids: N/A

ESS Laboratory Work Order: 21K0192
ESS Laboratory Sample ID: 21K0192-11
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.94** (0.500)		5310B		1	CCP	11/04/21 20:53	mg/L	[CALC]
Nitrate as N	**6.82** (0.210)		353.2		10	JLK	11/04/21 20:50	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	11/04/21 19:42	mg/L	DK10448
Total Nitrogen	**6.82** (0.200)		4500N		10	JLK	11/08/21 17:23	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0192

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DK10535 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.50		mg/L	2.500		100	80-120			
Manganese	0.498		mg/L	0.5000		100	80-120			
Classical Chemistry										
Batch DK10448 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.242		mg/L	0.2497		97	90-110			
Nitrite as N	0.242		mg/L	0.2497		97	90-110			
Batch DK10450 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.520		mg/L	0.5000		104	90-110			
Nitrate/Nitrite as N	0.520		mg/L	0.5000		104	90-110			
Batch DK10452 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	10.7	2.00	mg/L	10.30		104	80-120			
Batch DK10459 - General Preparation										
Blank										
Dissolved Organic Carbon (1)	ND	0.500	mg/L							
Dissolved Organic Carbon (2)	ND	0.500	mg/L							
LCS										
Dissolved Organic Carbon (1)	4.73	0.500	mg/L	5.000		95	80-120			
Dissolved Organic Carbon (2)	4.79	0.500	mg/L	5.000		96	80-120			
LCS Dup										
Dissolved Organic Carbon (1)	4.57	0.500	mg/L	5.000		91	80-120	3	20	
Dissolved Organic Carbon (2)	4.61	0.500	mg/L	5.000		92	80-120	4	20	
Methane / Ethane / Ethene by Headspace GCFID (RSK175)										
Batch DK11029 - No Prep										

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0192

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Methane / Ethane / Ethene by Headspace GCFID (RSK175)										
Batch DK11029 - No Prep										
Blank										
Ethane	ND	3.0	ug/L							
Ethene	ND	5.0	ug/L							
Methane	ND	2.0	ug/L							
LCS										
Ethane	49.3	3.0	ug/L	68.00		72	60-140			
Ethene	44.7	5.0	ug/L	64.00		70	60-140			
Methane	23.5	2.0	ug/L	36.00		65	60-140			
LCS Dup										
Ethane	50.7	3.0	ug/L	68.00		74	60-140	3	30	
Ethene	45.9	5.0	ug/L	64.00		72	60-140	3	30	
Methane	23.9	2.0	ug/L	36.00		66	60-140	2	30	

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0192

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0192

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ESS Courier

ESS Project ID: 21K0192
Date Received: 11/3/2021
Project Due Date: 11/10/2021
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 5 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** (Yes) / No / NA
10. Were any analyses received outside of hold time? Yes / (No)

11. Any Subcontracting needed? Yes / (No)
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / (No)
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA

13. Are the samples properly preserved? (Yes) / No
    a. If metals preserved upon receipt: Date: Time: By:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

14. Was there a need to contact Project Manager? Yes / (No)
    a. Was there a need to contact the client? Yes / (No)
    Who was contacted? Date: Time: By:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	225874	Yes	N/A	Yes	1L Poly	H2SO4	
1	225885	Yes	N/A	Yes	250 mL Poly	NP	
1	225896	Yes	N/A	Yes	250 mL Poly	NP	
2	225875	Yes	N/A	Yes	1L Poly	H2SO4	
2	225886	Yes	N/A	Yes	250 mL Poly	NP	
2	225897	Yes	N/A	Yes	250 mL Poly	NP	
3	225876	Yes	N/A	Yes	1L Poly	H2SO4	
3	225887	Yes	N/A	Yes	250 mL Poly	NP	
3	225898	Yes	N/A	Yes	250 mL Poly	NP	
4	225877	Yes	N/A	Yes	1L Poly	H2SO4	
4	225888	Yes	N/A	Yes	250 mL Poly	NP	
4	225899	Yes	N/A	Yes	250 mL Poly	NP	
5	225878	Yes	N/A	Yes	1L Poly	H2SO4	
5	225889	Yes	N/A	Yes	250 mL Poly	NP	
5	225900	Yes	N/A	Yes	250 mL Poly	NP	
6	225879	Yes	N/A	Yes	1L Poly	H2SO4	

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

ESS Project ID: 21K0192
Date Received: 11/3/2021

6	225890	Yes	N/A	Yes	250 mL Poly	NP
6	225901	Yes	N/A	Yes	250 mL Poly	NP
7	225880	Yes	N/A	Yes	1L Poly	H2SO4
7	225891	Yes	N/A	Yes	250 mL Poly	NP
7	225902	Yes	N/A	Yes	250 mL Poly	NP
8	225881	Yes	N/A	Yes	1L Poly	H2SO4
8	225892	Yes	N/A	Yes	250 mL Poly	NP
8	225903	Yes	N/A	Yes	250 mL Poly	NP
9	225882	Yes	N/A	Yes	1L Poly	H2SO4
9	225893	Yes	N/A	Yes	250 mL Poly	NP
9	225904	Yes	N/A	Yes	250 mL Poly	NP
10	225883	Yes	N/A	Yes	1L Poly	H2SO4
10	225894	Yes	N/A	Yes	250 mL Poly	NP
10	225926	Yes	N/A	Yes	250 mL Amber	NP
10	225928	Yes	No	Yes	VOA Vial	HCl
10	225929	Yes	No	Yes	VOA Vial	HCl
11	225884	Yes	N/A	Yes	1L Poly	H2SO4
11	225895	Yes	N/A	Yes	250 mL Poly	NP
11	225927	Yes	N/A	Yes	250 mL Amber	NP

2nd Review

Were all containers scanned into storage/lab? Initials _____ Yes / No

Are barcode labels on correct containers? Yes / No / NA

Are all Flashpoint stickers attached/container ID # circled? Yes / No / NA

Are all Hex Chrome stickers attached? Yes / No / NA

Are all QC stickers attached? Yes / No / NA

Are VOA stickers attached if bubbles noted? Yes / No / NA

Completed By: _____ Date & Time: 11/3/21 1943

Reviewed By: _____ Date & Time: 11/3/21 2016

ESS Laboratory

Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 210192

Turn Time	5	Days
Regulatory State	Massachusetts	
Is this project for any of the following?:	○CT RCP ○MA MCP ○RGP	
Reporting Limits		
Electonic Deliverables	☐Data Checker ☐Excel ☐Other (Please Specify →)	

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB

	Address	
Julianne Marrion	250 Apollo Dr	

City	State	Zip Code	PO #
Chelmsford	MA	01824	

Telephone Number	FAX Number	Email Address
978-905-2419		julianne.marrion@aecom.com

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: Total Nitrogen	Nitrate, Nitrite	Lab Filter Dissolved Fe, Mn	DOC	Methane
1	11/03/21	1000	Grab	Ground Water	MW-RI-258	X	X	X		
2	11/03/21	1040	Grab	Ground Water	MW-NA-2-88	X	X	X		
3	11/03/21	1145	Grab	Ground Water	MW-BR-2-96	X	X	X		
4	11/03/21	1230	Grab	Ground Water	MW-BR-1-98	X	X	X		
5	11/03/21	1150	Grab	Ground Water	MW-BR-3-100	X	X	X		
6	11/03/21	1225	Grab	Ground Water	MW-BR-3-60	X	X	X		
7	11/03/21	1420	Grab	Ground Water	MW-BR-5-90	X	X	X		
8	11/03/21	1415	Grab	Ground Water	MW-BR-6-100	X	X	X		
9	11/03/21	1515	Grab	Ground Water	MW-BR-4-100	X	X	X		
10	11/03/21	1535	Grab	Ground Water	MW-B1050B	X	X		X	X

Container Type:	AC-Air Cassette AG-Amber Glass B-BOD Bottle C-Cubitainer J-Jar O-Other P-Poly S-Sterile V-Vial	P	P	P	AG	V
Container Volume:	1-100 mL 2-2.5 gal 3-250 mL 4-300 mL 5-500 mL 6-1L 7-VOA 8-2 oz 9-4 oz 10-8 oz 11-Other*	6	3	3	3	7
Preservation Code:	1-Non Preserved 2-HCl 3-H2SO4 4-HNO3 5-NaOH 6-Methanol 7-Na2S2O3 8-ZnAce, NaOH 9-NH4Cl 10-DI H2O 11-Other*	3	1	1	1	2
	Number of Containers per Sample:	1	1	1	1	2

Laboratory Use Only

Cooler Present: ✓ ○Drop Off
Seals Intact: ✓ ○Pickup
Cooler Temperature: ICE 5.0 °C

Sampled by : Briley Barra AECOM Briley Barra

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
Briley Barra 11/03/21 1750	11/3/21 1750	11/3/21 18:45	Courtney Davis 1855 11/3/21
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

ESS Laboratory
Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 21K0192

Turn Time	5	Days
Regulatory State	Massachusetts	
Is this project for any of the following?:	○CT RCP ○MA MCP ○RGP	
Reporting Limits		
Electonic Deliverables	☐Data Checker ☐Excel ☐Other (Please Specify →)	

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB
Address		
Julianne Marrion	250 Apollo Dr	
City	**State**	**Zip Code** / **PO #**
Chelmsford	MA	01824
Telephone Number	**FAX Number**	**Email Address**
978-905-2419		julianne.marrion@aecom.com

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: Total Nitrogen	Nitrate, Nitrite	Lab Filter Dissolved Fe, Mn	DOC	Methane
11	11/03/21	1625	Grab	Ground Water	MW-3X2C	X	X		X	
			Grab	Ground Water						
			Grab	Ground Water						
			Grab	Ground Water						
			Grab	Ground Water						
			Grab	Ground Water						
			Grab	Ground Water						
			Grab	Ground Water						
			Grab	Ground Water						
			Grab	Ground Water						

BR 1103 PM

Container Type:	AC-Air Cassette	AG-Amber Glass	B-BOD Bottle	C-Cubitainer	J-Jar	O-Other	P-Poly	S-Sterile	V-Vial	P	P	P	AG	V
Container Volume:	1-100 mL	2-2.5 gal	3-250 mL	4-300 mL	5-500 mL	6-1L	7-VOA	8-2 oz	9-4 oz	10-8 oz	11-Other*	6	3	3	3	7
Preservation Code:	1-Non Preserved	2-HCl	3-H2SO4	4-HNO3	5-NaOH	6-Methanol	7-Na2S2O3	8-ZnAce, NaOH	9-NH4Cl	10-DI H2O	11-Other*	3	1	1	1	2
											Number of Containers per Sample:	1	1	1	1	2

Laboratory Use Only
Cooler Present: ✓ ○Drop Off
Seals Intact: ✓ ○Pickup
Cooler Temperature: FC 5.0 °C

Sampled by : Briley Bama AECOM Briley Bama

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
Briley Bama 11/03/21 1750	11/04/21 17:50	11/3/21 18:55	Clayton Davis 11/4 855
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 21K0264

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 11:55 am, Nov 11, 2021

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0264

SAMPLE RECEIPT

The following samples were received on November 04, 2021 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
21K0264-01	MW-DV-1-100	Ground Water	200.7, 353.2, 4500N
21K0264-02	MW-DV-2-100	Ground Water	200.7, 353.2, 4500N
21K0264-03	MW-DV-3-100	Ground Water	200.7, 353.2, 4500N
21K0264-04	MW-DV-4-100	Ground Water	200.7, 353.2, 4500N
21K0264-05	MW-DV-5-100	Ground Water	200.7, 353.2, 4500N
21K0264-06	MW-DV-6-100	Ground Water	200.7, 353.2, 4500N

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0264

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0264

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0264

Dissolved Metals

Client Sample ID: MW-DV-1-100
Date Sampled: 11/04/21 12:00
Percent Solids: N/A

ESS Laboratory Sample ID: 21K0264-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed	I/V	F/V
Iron	**0.595**	mg/L	0.100	200.7	1	KJK	11/05/21 22:56	10	10
Manganese	**1.20**	mg/L	0.020	200.7	1	KJK	11/05/21 22:56	10	10

Client Sample ID: MW-DV-2-100
Date Sampled: 11/04/21 12:00
Percent Solids: N/A

ESS Laboratory Sample ID: 21K0264-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed	I/V	F/V
Iron	**2.48**	mg/L	0.100	200.7	1	KJK	11/05/21 23:11	10	10
Manganese	**1.08**	mg/L	0.020	200.7	1	KJK	11/05/21 23:11	10	10

Client Sample ID: MW-DV-3-100
Date Sampled: 11/04/21 11:15
Percent Solids: N/A

ESS Laboratory Sample ID: 21K0264-03
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed	I/V	F/V
Iron	**0.521**	mg/L	0.100	200.7	1	KJK	11/05/21 23:13	10	10
Manganese	**0.215**	mg/L	0.020	200.7	1	KJK	11/05/21 23:13	10	10

Client Sample ID: MW-DV-4-100
Date Sampled: 11/04/21 10:00
Percent Solids: N/A

ESS Laboratory Sample ID: 21K0264-04
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed	I/V	F/V
Iron	ND	mg/L	0.100	200.7	1	KJK	11/05/21 23:15	10	10
Manganese	**0.315**	mg/L	0.020	200.7	1	KJK	11/05/21 23:15	10	10

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0264

Dissolved Metals

Client Sample ID: MW-DV-5-100
Date Sampled: 11/04/21 11:10
Percent Solids: N/A

ESS Laboratory Sample ID: 21K0264-05
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed	I/V	F/V
Iron	**0.798**	mg/L	0.100	200.7	1	KJK	11/05/21 23:17	10	10
Manganese	**0.556**	mg/L	0.020	200.7	1	KJK	11/05/21 23:17	10	10

Client Sample ID: MW-DV-6-100
Date Sampled: 11/04/21 10:20
Percent Solids: N/A

ESS Laboratory Sample ID: 21K0264-06
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed	I/V	F/V
Iron	ND	mg/L	0.100	200.7	1	KJK	11/05/21 23:19	10	10
Manganese	**0.755**	mg/L	0.020	200.7	1	KJK	11/05/21 23:19	10	10

Classical Chemistry

Client Sample ID: MW-DV-1-100
Date Sampled: 11/04/21 12:00
Percent Solids: N/A

ESS Laboratory Sample ID: 21K0264-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Nitrate as N	**0.985**	mg/L	0.0500	353.2	2	JLK	11/04/21 22:55
Nitrite as N	**0.168**	mg/L	0.010	353.2	1	JLK	11/04/21 21:24
Total Nitrogen	**1.15**	mg/L	0.200	4500N	2	JLK	11/09/21 17:45

Client Sample ID: MW-DV-2-100
Date Sampled: 11/04/21 12:00
Percent Solids: N/A

ESS Laboratory Sample ID: 21K0264-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Nitrate as N	**0.158**	mg/L	0.0300	353.2	1	JLK	11/04/21 22:24

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0264

Classical Chemistry

Nitrite as N	ND	mg/L	0.010	353.2	1	JLK	11/04/21 21:25
Total Nitrogen	ND	mg/L	0.200	4500N	1	JLK	11/09/21 17:46

Client Sample ID: MW-DV-3-100
Date Sampled: 11/04/21 11:15
Percent Solids: N/A

ESS Laboratory Sample ID: 21K0264-03
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Nitrate as N	**1.12**	mg/L	0.0500	353.2	2	JLK	11/04/21 22:56
Nitrite as N	**0.064**	mg/L	0.010	353.2	1	JLK	11/04/21 21:26
Total Nitrogen	**1.19**	mg/L	0.200	4500N	2	JLK	11/09/21 17:47

Client Sample ID: MW-DV-4-100
Date Sampled: 11/04/21 10:00
Percent Solids: N/A

ESS Laboratory Sample ID: 21K0264-04
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Nitrate as N	**0.621**	mg/L	0.0300	353.2	1	JLK	11/04/21 22:26
Nitrite as N	**0.053**	mg/L	0.010	353.2	1	JLK	11/04/21 21:27
Total Nitrogen	**0.674**	mg/L	0.200	4500N	1	JLK	11/09/21 17:48

Client Sample ID: MW-DV-5-100
Date Sampled: 11/04/21 11:10
Percent Solids: N/A

ESS Laboratory Sample ID: 21K0264-05
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Nitrate as N	**0.106**	mg/L	0.0300	353.2	1	JLK	11/04/21 22:27
Nitrite as N	ND	mg/L	0.010	353.2	1	JLK	11/04/21 21:28
Total Nitrogen	ND	mg/L	0.200	4500N	1	JLK	11/09/21 17:49

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0264

Classical Chemistry

Client Sample ID: MW-DV-6-100
Date Sampled: 11/04/21 10:20
Percent Solids: N/A

ESS Laboratory Sample ID: 21K0264-06
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Nitrate as N	**1.09**	mg/L	0.0500	353.2	2	JLK	11/04/21 22:57
Nitrite as N	**0.019**	mg/L	0.010	353.2	1	JLK	11/04/21 21:29
Total Nitrogen	**1.11**	mg/L	0.200	4500N	2	JLK	11/09/21 17:50

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0264

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DK10536 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.50		mg/L	2.500		100	80-120			
Manganese	0.498		mg/L	0.5000		100	80-120			
Classical Chemistry										
Batch DK10449 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.242		mg/L	0.2497		97	90-110			
Nitrite as N	0.242		mg/L	0.2497		97	90-110			
Batch DK10451 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.529		mg/L	0.5000		106	90-110			
Nitrate/Nitrite as N	0.529		mg/L	0.5000		106	90-110			
Batch DK10860 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	11.6	2.00	mg/L	10.30		113	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0264

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21K0264

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory
Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 21K0264

Turn Time	5	Days	
Regulatory State	Massachusetts		
Is this project for any of the following?:	○CT RCP	○MA MCP	○RGP
Reporting Limits			
Electonic Deliverables	☐Data Checker	☐Excel	☐Other (Please Specify →)

Company Name: AECOM	Project #: 60476644	Project Name: Orleans PRB	
Julianne Marrion	Address: 250 Apollo Dr		
City: Chelmsford	State: MA	Zip Code: 01824	PO #:
Telephone Number: 978-905-2419	FAX Number:	Email Address: julianne.marrion@aecom.com	

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Total Nitrogen	Nitrate, Nitrite	Lab Filter Dissolved Fe, Mn	DOC	Methane
1	11/04/21	1200	Grab	Ground Water	MW-DU-1-100	X	X	X		
2	11/04/21	1200	Grab	Ground Water	MW-DU-2-100	X	X	X		
3	11/04/21	1115	Grab	Ground Water	MW-DU-3-100	X	X	X		
4	11/04/21	1000	Grab	Ground Water	MW-DU-4-100	X	X	X		
5	11/04/21	1110	Grab	Ground Water	MW-DU-5-100	X	X	X		
6	11/04/21	1020	Grab	Ground Water	MW-DU-6-100	X	X	X		
			Grab	Ground Water						
			Grab	Ground Water						
			Grab	Ground Water						
			Grab	Ground Water						

BB 11/04/21

Container Type: AC-Air Cassette AG-Amber Glass B-BOD Bottle C-Cubitainer J-Jar O-Other P-Poly S-Sterile V-Vial

Container Volume: 1-100 mL 2-2.5 gal 3-250 mL 4-300 mL 5-500 mL 6-1L 7-VOA 8-2 oz 9-4 oz 10-8 oz 11-Other*

Preservation Code: 1-Non Preserved 2-HCl 3-H2SO4 4-HNO3 5-NaOH 6-Methanol 7-Na2S2O3 8-ZnAce, NaOH 9-NH4Cl 10-DI H2O 11-Other*

Number of Containers per Sample:	P	P	P	AG	V
	6	3	3	3	7
	3	1	1	1	2
	1	1	1	1	2

Laboratory Use Only

Cooler Present: _____ ○Drop Off
Seals Intact: _____ ○Pickup
Cooler Temperature: -1.7 °C Ice

Sampled by: Briley Barra AECOM Briley-Barra

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
Hallie Allen 11/04/21 1519	11.4.21 1519		
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

CERTIFICATE OF ANALYSIS

Thomas Parece
AECOM Environment - ENSR
250 Apollo Drive
Chelmsford, MA 01824

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 21L0810

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 4:24 pm, Dec 29, 2021

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21L0810

SAMPLE RECEIPT

The following samples were received on December 21, 2021 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
21L0810-01	DU-1-68	Ground Water	200.7, 353.2, 4500N
21L0810-02	BR-6-78	Ground Water	200.7, 353.2, 4500N

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21L0810

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21L0810

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-1-68
Date Sampled: 12/21/21 09:45
Percent Solids: N/A

ESS Laboratory Work Order: 21L0810
ESS Laboratory Sample ID: 21L0810-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	12/22/21 18:46	10	10	DL12237
Manganese	**0.769** (0.020)		200.7		1	KJK	12/22/21 18:46	10	10	DL12237

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-1-68
Date Sampled: 12/21/21 09:45
Percent Solids: N/A

ESS Laboratory Work Order: 21L0810
ESS Laboratory Sample ID: 21L0810-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**0.782** (0.0300)		353.2		1	JLK	12/21/21 22:01	mg/L	[CALC]
Total Nitrogen	**1.09** (0.200)		4500N		1	JLK	12/27/21 16:46	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-6-78
Date Sampled: 12/21/21 14:15
Percent Solids: N/A

ESS Laboratory Work Order: 21L0810
ESS Laboratory Sample ID: 21L0810-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.347** (0.100)		200.7		1	KJK	12/22/21 18:58	10	10	DL12237
Manganese	**0.274** (0.020)		200.7		1	KJK	12/22/21 18:58	10	10	DL12237

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-6-78
Date Sampled: 12/21/21 14:15
Percent Solids: N/A

ESS Laboratory Work Order: 21L0810
ESS Laboratory Sample ID: 21L0810-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**1.45** (0.0500)		353.2		2	JLK	12/21/21 22:17	mg/L	[CALC]
Total Nitrogen	**1.45** (0.200)		4500N		2	JLK	12/27/21 16:47	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21L0810

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DL12237 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.49		mg/L	2.500		99	80-120			
Manganese	0.505		mg/L	0.5000		101	80-120			
Classical Chemistry										
Batch DL12140 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.251		mg/L	0.2497		101	90-110			
Batch DL12141 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.496		mg/L	0.5000		99	90-110			
Nitrate/Nitrite as N	0.496		mg/L	0.5000		99	90-110			
Batch DL12260 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	20.1	2.00	mg/L	19.90		101	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21L0810

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21L0810

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ESS Courier

ESS Project ID: 21L0810
Date Received: 12/21/2021
Project Due Date: 12/29/2021
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 2.1 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** Yes / No / NA
10. Were any analyses received outside of hold time? Yes / No

11. Any Subcontracting needed? Yes / No
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / No
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA

13. Are the samples properly preserved? Yes / No
    a. If metals preserved upon receipt: Date: Time: By:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

14. Was there a need to contact Project Manager? Yes / No
    a. Was there a need to contact the client? Yes / No
    Who was contacted? Date: Time: By:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	244572	Yes	N/A	Yes	250 mL Poly	NP	
1	244574	Yes	N/A	Yes	250 mL Poly	H2SO4	
1	244705	Yes	N/A	Yes	250 mL Poly	NP	
2	244573	Yes	N/A	Yes	250 mL Poly	NP	
2	244575	Yes	N/A	Yes	250 mL Poly	H2SO4	
2	244706	Yes	N/A	Yes	250 mL Poly	NP	

2nd Review
Were all containers scanned into storage/lab? Initials TD
Are barcode labels on correct containers? Yes / No
Are all Flashpoint stickers attached/container ID # circled? Yes / No / NA
Are all Hex Chrome stickers attached? Yes / No / NA
Are all QC stickers attached? Yes / No / NA
Are VOA stickers attached if bubbles noted? Yes / No / NA

Completed By: Taylor Davis Date & Time: 12/21/21 2010

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

ESS Project ID: 21L0810

Date Received: 12/21/2021

Reviewed By: [signature]

Date & Time: 12/21/21 2034

CHAIN OF CUSTODY

185 Frances Avenue
Cranston, RI 02921
Phone: 401-461-7181
Fax: 401-461-4486
www.esslaboratory.com

ESS Lab # 210810 | Page of

Turn Time: ☐ >5 ☐ 5 ☐ 4 ☐ 3 ☐ 2 ☐ 1 ☐ Same Day

Regulatory State: Criteria:

Is this project for any of the following?: ☐ CT RCP ☒ MA MCP ☐ RGP ☐ Permit ☐ 401 WQ

ELECTRONIC DELIVERABLES (Final Reports are PDF)
☐ Limit Checker ☐ State Forms ☐ EQuIS
☐ Excel ☐ Hard Copy ☐ Enviro Data
☐ CLP-Like Package ☐ Other (Specify) →

CLIENT INFORMATION

Client: AECOM
Address: 250 Apollo Dr
Chelmsford MA
Phone:
Email Distribution List:

PROJECT INFORMATION

Project Name: Orleans
Project Location:
Project Number: 60476644
Project Manager: Tom Parece
Bill to:
PO#:
Quote#:

Client acknowledges that sampling is compliant with all EPA / State regulatory programs

REQUESTED ANALYSES

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Total N	Nitrate	Dissolved Mn	Total Number of Bottles
1	12/21/21	0945	GW	GW	DU-1-68	X	X	X	
2	12/21/21	1415	GW	GW	BR-6-78	X	X	X	

Container Type: AC-Air Cassette AG-Amber Glass B-BOD Bottle C-Cubitainer J-Jar O-Other P-Poly S-Sterile V-Vial — P P P

Container Volume: 1-100 mL 2-2.5 gal 3-250 mL 4-300 mL 5-500 mL 6-1L 7-VOA 8-2 oz 9-4 oz 10-8 oz 11-Other* — 3 3 3

Preservation Code: 1-Non Preserved 2-HCl 3-H2SO4 4-HNO3 5-NaOH 6-Methanol 7-Na2S2O3 8-ZnAce, NaOH 9-NH4Cl 10-DI H2O 11-Other* — 3 1 1

Sampled by: Briley Barra AECOM

Chain needs to be filled out neatly and completely for on time delivery.

Laboratory Use Only
Cooler Temperature (°C): 2.1
ice

Comments: * Please specify "Other" preservative and containers types in this space

All samples submitted are subject to ESS Laboratory's payment terms and conditions.

Dissolved Filtration
☐ Lab Filter

Relinquished by (Signature)	Date	Time	Received by (Signature)	Relinquished by (Signature)	Date	Time	Received by (Signature)
Briley Barra	12/21/21	1740	[signature] 12/21/21 17:41	[signature]	12/22/21	19:09	Mayor Davis

CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 21L0889

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 1:40 pm, Jan 03, 2022

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21L0889

SAMPLE RECEIPT

The following samples were received on December 22, 2021 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
21L0889-01	DU-3-76	Ground Water	200.7, 353.2, 4500N, 5310B
21L0889-02	DU-3-51	Ground Water	200.7, 353.2, 4500N
21L0889-03	DU-2-63	Ground Water	200.7, 353.2, 4500N
21L0889-04	DU-2-26	Ground Water	200.7, 353.2, 4500N
21L0889-05	DU-4-76	Ground Water	200.7, 353.2, 4500N
21L0889-06	DU-4-52	Ground Water	200.7, 353.2, 4500N
21L0889-07	DU-5-67	Ground Water	200.7, 353.2, 4500N
21L0889-08	DU-5-34	Ground Water	200.7, 353.2, 4500N

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21L0889

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

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Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21L0889

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-3-76
Date Sampled: 12/22/21 13:10
Percent Solids: N/A

ESS Laboratory Work Order: 21L0889
ESS Laboratory Sample ID: 21L0889-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.308** (0.100)		200.7		1	KJK	12/23/21 16:56	10	10	DL12339
Manganese	**0.492** (0.020)		200.7		1	KJK	12/23/21 16:56	10	10	DL12339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-3-76
Date Sampled: 12/22/21 13:10
Percent Solids: N/A

ESS Laboratory Work Order: 21L0889
ESS Laboratory Sample ID: 21L0889-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.37** (0.500)		5310B		1	CCP	12/28/21 0:26	mg/L	[CALC]
Nitrate as N	**2.56** (0.210)		353.2		10	JLK	12/23/21 22:02	mg/L	[CALC]
Total Nitrogen	**2.57** (0.200)		4500N		10	JLK	12/27/21 17:42	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-3-51
Date Sampled: 12/22/21 13:15
Percent Solids: N/A

ESS Laboratory Work Order: 21L0889
ESS Laboratory Sample ID: 21L0889-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	12/23/21 16:58	10	10	DL12339
Manganese	**0.101** (0.020)		200.7		1	KJK	12/23/21 16:58	10	10	DL12339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-3-51
Date Sampled: 12/22/21 13:15
Percent Solids: N/A

ESS Laboratory Work Order: 21L0889
ESS Laboratory Sample ID: 21L0889-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**0.821** (0.0300)		353.2		1	JLK	12/23/21 21:33	mg/L	[CALC]
Total Nitrogen	**1.07** (0.200)		4500N		1	JLK	12/27/21 17:43	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-2-63
Date Sampled: 12/22/21 14:10
Percent Solids: N/A

ESS Laboratory Work Order: 21L0889
ESS Laboratory Sample ID: 21L0889-03
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	12/23/21 17:01	10	10	DL12339
Manganese	**0.174** (0.020)		200.7		1	KJK	12/23/21 17:01	10	10	DL12339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-2-63
Date Sampled: 12/22/21 14:10
Percent Solids: N/A

ESS Laboratory Work Order: 21L0889
ESS Laboratory Sample ID: 21L0889-03
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**1.19** (0.0500)		353.2		2	JLK	12/23/21 22:06	mg/L	[CALC]
Total Nitrogen	**1.21** (0.200)		4500N		2	JLK	12/27/21 17:44	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-2-26
Date Sampled: 12/22/21 14:15
Percent Solids: N/A

ESS Laboratory Work Order: 21L0889
ESS Laboratory Sample ID: 21L0889-04
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.107** (0.100)		200.7		1	KJK	12/23/21 17:03	10	10	DL12339
Manganese	ND (0.020)		200.7		1	KJK	12/23/21 17:03	10	10	DL12339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-2-26
Date Sampled: 12/22/21 14:15
Percent Solids: N/A

ESS Laboratory Work Order: 21L0889
ESS Laboratory Sample ID: 21L0889-04
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**2.69** (0.110)		353.2		5	JLK	12/23/21 22:12	mg/L	[CALC]
Total Nitrogen	**3.43** (0.200)		4500N		5	JLK	12/27/21 17:50	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-4-76
Date Sampled: 12/22/21 15:20
Percent Solids: N/A

ESS Laboratory Work Order: 21L0889
ESS Laboratory Sample ID: 21L0889-05
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.798** (0.100)		200.7		1	KJK	12/23/21 17:05	10	10	DL12339
Manganese	**0.399** (0.020)		200.7		1	KJK	12/23/21 17:05	10	10	DL12339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-4-76
Date Sampled: 12/22/21 15:20
Percent Solids: N/A

ESS Laboratory Work Order: 21L0889
ESS Laboratory Sample ID: 21L0889-05
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**1.32** (0.0500)		353.2		2	JLK	12/23/21 22:13	mg/L	[CALC]
Total Nitrogen	**1.35** (0.200)		4500N		2	JLK	12/27/21 17:51	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-4-52
Date Sampled: 12/22/21 15:15
Percent Solids: N/A

ESS Laboratory Work Order: 21L0889
ESS Laboratory Sample ID: 21L0889-06
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	12/23/21 17:07	10	10	DL12339
Manganese	**0.151** (0.020)		200.7		1	KJK	12/23/21 17:07	10	10	DL12339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-4-52
Date Sampled: 12/22/21 15:15
Percent Solids: N/A

ESS Laboratory Work Order: 21L0889
ESS Laboratory Sample ID: 21L0889-06
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**0.810** (0.0300)		353.2		1	JLK	12/23/21 21:36	mg/L	[CALC]
Total Nitrogen	**0.824** (0.200)		4500N		1	JLK	12/27/21 17:52	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-5-67
Date Sampled: 12/22/21 16:10
Percent Solids: N/A

ESS Laboratory Work Order: 21L0889
ESS Laboratory Sample ID: 21L0889-07
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.128** (0.100)		200.7		1	KJK	12/23/21 17:09	10	10	DL12339
Manganese	**0.048** (0.020)		200.7		1	KJK	12/23/21 17:09	10	10	DL12339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-5-67
Date Sampled: 12/22/21 16:10
Percent Solids: N/A

ESS Laboratory Work Order: 21L0889
ESS Laboratory Sample ID: 21L0889-07
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**1.45** (0.0500)		353.2		2	JLK	12/23/21 22:14	mg/L	[CALC]
Total Nitrogen	**1.73** (0.200)		4500N		2	JLK	12/27/21 17:52	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-5-34
Date Sampled: 12/22/21 16:15
Percent Solids: N/A

ESS Laboratory Work Order: 21L0889
ESS Laboratory Sample ID: 21L0889-08
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	12/23/21 17:12	10	10	DL12339
Manganese	**0.035** (0.020)		200.7		1	KJK	12/23/21 17:12	10	10	DL12339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-5-34
Date Sampled: 12/22/21 16:15
Percent Solids: N/A

ESS Laboratory Work Order: 21L0889
ESS Laboratory Sample ID: 21L0889-08
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**1.13** (0.0500)		353.2		2	JLK	12/23/21 22:15	mg/L	[CALC]
Total Nitrogen	**1.13** (0.200)		4500N		2	JLK	12/27/21 17:53	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21L0889

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DL12339 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.51		mg/L	2.500		100	80-120			
Manganese	0.509		mg/L	0.5000		102	80-120			
Classical Chemistry										
Batch DL12336 - General Preparation										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	19.3	2.00	mg/L	19.90		97	80-120			
Batch DL12341 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.255		mg/L	0.2497		102	90-110			
Batch DL12343 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.505		mg/L	0.5000		101	90-110			
Nitrate/Nitrite as N	0.505		mg/L	0.5000		101	90-110			
Batch DL12761 - General Preparation										
Blank										
Dissolved Organic Carbon (1)	ND	0.500	mg/L							
Dissolved Organic Carbon (2)	ND	0.500	mg/L							
LCS										
Dissolved Organic Carbon (1)	5.10	0.500	mg/L	5.000		102	80-120			
Dissolved Organic Carbon (2)	4.94	0.500	mg/L	5.000		99	80-120			
LCS Dup										
Dissolved Organic Carbon (1)	4.83	0.500	mg/L	5.000		97	80-120	5	20	
Dissolved Organic Carbon (2)	4.80	0.500	mg/L	5.000		96	80-120	3	20	

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21L0889

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 21L0889

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ESS Courier

ESS Project ID: 21L0889
Date Received: 12/22/2021
Project Due Date: 12/30/2021
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 3.9 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** (Yes) No / NA
10. Were any analyses received outside of hold time? Yes (No)

11. Any Subcontracting needed? Yes / (No)
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / (No)
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA

13. Are the samples properly preserved? (Yes) / No
    a. If metals preserved upon receipt: Date: Time: By:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

14. Was there a need to contact Project Manager? Yes (No)
    a. Was there a need to contact the client? Yes / No
    Who was contacted? Date: Time: By:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	245228	Yes	N/A	Yes	250 mL Poly	NP	
1	245229	Yes	N/A	Yes	250 mL Poly	NP	
1	245244	Yes	N/A	Yes	250 mL Poly	H2SO4	
1	245252	Yes	N/A	Yes	1L Amber	NP	
2	245230	Yes	N/A	Yes	250 mL Poly	NP	
2	245231	Yes	N/A	Yes	250 mL Poly	NP	
2	245245	Yes	N/A	Yes	250 mL Poly	H2SO4	
3	245232	Yes	N/A	Yes	250 mL Poly	NP	
3	245233	Yes	N/A	Yes	250 mL Poly	NP	
3	245246	Yes	N/A	Yes	250 mL Poly	H2SO4	
4	245234	Yes	N/A	Yes	250 mL Poly	NP	
4	245235	Yes	N/A	Yes	250 mL Poly	NP	
4	245247	Yes	N/A	Yes	250 mL Poly	H2SO4	
5	245236	Yes	N/A	Yes	250 mL Poly	NP	
5	245237	Yes	N/A	Yes	250 mL Poly	NP	
5	245248	Yes	N/A	Yes	250 mL Poly	H2SO4	

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

ESS Project ID: 21L0889

Date Received: 12/22/2021

6	245238	Yes	N/A	Yes	250 mL Poly	NP
6	245239	Yes	N/A	Yes	250 mL Poly	NP
6	245249	Yes	N/A	Yes	250 mL Poly	H2SO4
7	245240	Yes	N/A	Yes	250 mL Poly	NP
7	245241	Yes	N/A	Yes	250 mL Poly	NP
7	245250	Yes	N/A	Yes	250 mL Poly	H2SO4
8	245242	Yes	N/A	Yes	250 mL Poly	NP
8	245243	Yes	N/A	Yes	250 mL Poly	NP
8	245251	Yes	N/A	Yes	250 mL Poly	H2SO4

2nd Review

Were all containers scanned into storage/lab? Initials KL

Are barcode labels on correct containers? Yes / No

Are all Flashpoint stickers attached/container ID # circled? Yes / No / NA

Are all Hex Chrome stickers attached? Yes / No / NA

Are all QC stickers attached? Yes / No / NA

Are VOA stickers attached if bubbles noted? Yes / No / NA

Completed By: [signature] Date & Time: 12-22-21 19:14

Reviewed By: [signature] Date & Time: 12/22/21 1926

ESS Laboratory

Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.essiaboratory.com

CHAIN OF CUSTODY

ESS Lab # 21L0989

Turn Time	5 Days
Regulatory State	Massachusetts
Is this project for any of the following?	○CT RCP ○MA MCP ○RGP
Reporting Limits	
Electonic Deliverables	☐Data Checker ☐Excel ☐Other (Please Specify →)

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB

Contact Person	Address
Julianne Marrion	250 Apollo Dr

City	State	Zip Code	PO #
Chelmsford	MA	01824	

Telephone Number	FAX Number	Email Address
978-905-2419		julianne.marrion@aecom.com

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: NO2, NO3, Sulfate	TN, Ammonia	Lab Filter Dissolved Fe, Mn	DOC	Lab Filtered Dissolved Arsenic	Methane	TOT N	Nitrate
1	12/22/21	1310	Grab	Ground Water	DU-3-76			X	X			X	X
2	12/22/21	1315	Grab	Ground Water	DU-3-51			X				X	X
3	12/22/21	1410	Grab	Ground Water	DU-2-63			X				X	X
4	12/22/21	1415	Grab	Ground Water	DU-2-26			X				X	X
5	12/22/21	1520	Grab	Ground Water	DU-4-76			X				X	X
6	12/22/21	1515	Grab	Ground Water	DU-4-52			X				X	X
7	12/22/21	1610	Grab	Ground Water	DU-5-67			X				X	X
8	12/22/21	1615	GRAB	GW	DU-5-34			X				X	X
Container Type:	AC-Air Cassette AG-Amber Glass B-BOD Bottle C-Cubitainer J-Jar O-Other P-Poly S-Sterile V-Vial							P	AG			P	P
Container Volume:	1-100 mL 2-2.5 gal 3-250 mL 4-300 mL 5-500 mL 6-1L 7-VOA 8-2 oz 9-4 oz 10-8 oz 11-Other*							3	6			3	3
Preservation Code:	1-Non Preserved 2-HCl 3-H2SO4 4-HNO3 5-NaOH 6-MeOH 7-Na2S2O3 8-ZnAce, NaOH 9-NH4Cl 10-DI H2O 11-Other*							1	1			3	1
					Number of Containers per Sample:			1	1			1	1

Laboratory Use Only

Cooler Present: yes ○Drop Off
Seals Intact: ○Pickup
Cooler Temperature: 3.8 °C IR

Sampled by : Briley Barra

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
Briley Barra AECOM 12/22/21 1740	12/22/21 17:40	12/22/21 18:53	12-22-21 1852
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 22A0694

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 1:07 pm, Jan 31, 2022

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0694

SAMPLE RECEIPT

The following samples were received on January 24, 2022 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
22A0694-01	DU-6-67	Ground Water	200.7, 353.2, 4500N

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0694

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0694

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-6-67
Date Sampled: 01/24/22 15:05
Percent Solids: N/A

ESS Laboratory Work Order: 22A0694
ESS Laboratory Sample ID: 22A0694-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.456** (0.100)		200.7		1	KJK	01/26/22 2:09	10	10	DA22446
Manganese	**0.080** (0.020)		200.7		1	KJK	01/26/22 2:09	10	10	DA22446

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-6-67
Date Sampled: 01/24/22 15:05
Percent Solids: N/A

ESS Laboratory Work Order: 22A0694
ESS Laboratory Sample ID: 22A0694-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**5.20** (0.210)		353.2		10	JLK	01/25/22 20:56	mg/L	[CALC]
Total Nitrogen	**5.80** (0.200)		4500N		10	EEM	01/26/22 14:58	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0694

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DA22446 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.51		mg/L	2.500		100	80-120			
Manganese	0.500		mg/L	0.5000		100	80-120			
Classical Chemistry										
Batch DA22531 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.257		mg/L	0.2497		103	90-110			
Batch DA22532 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.518		mg/L	0.5000		104	90-110			
Nitrate/Nitrite as N	0.518		mg/L	0.5000		104	90-110			
Batch DA22533 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	22.0	2.00	mg/L	19.90		110	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0694

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0694

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ESS Courier

ESS Project ID: 22A0694
Date Received: 1/24/2022
Project Due Date: 1/31/2022
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 2.1 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** Yes / No / NA
10. Were any analyses received outside of hold time? Yes / No

11. Any Subcontracting needed? Yes / No
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / No
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA
13. Are the samples properly preserved? Yes / No
    a. If metals preserved upon receipt: Date: Time: By:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

14. Was there a need to contact Project Manager? Yes / No
    a. Was there a need to contact the client? Yes / No
    Who was contacted? Date: Time: By:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	252752	Yes	N/A	Yes	250 mL Poly	H2SO4	
1	252753	Yes	N/A	Yes	250 mL Poly	NP	
1	252754	Yes	N/A	Yes	250 mL Poly	NP	

2nd Review
Were all containers scanned into storage/lab? Initials KL Yes / No
Are barcode labels on correct containers? Yes / No / NA
Are all Flashpoint stickers attached/container ID # circled? Yes / No / NA
Are all Hex Chrome stickers attached? Yes / No / NA
Are all QC stickers attached? Yes / No / NA
Are VOA stickers attached if bubbles noted? Yes / No / NA

Completed By: Date & Time: 1-24-22 1719
Reviewed By: Date & Time: 1/24/22 1721

ESS Laboratory
Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 22A0694

Turn Time	5	Days
Regulatory State	Massachusetts	
Is this project for any of the following?:	○CT RCP ○MA MCP ○RGP	

Reporting Limits

Electonic Deliverables ☐Data Checker ☐Excel ☐Other (Please Specify →)

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB

Contact Person	Address
Julianne Marrion	250 Apollo Dr

City	State	Zip Code	PO #
Chelmsford	MA	01824	

Telephone Number	FAX Number	Email Address
978-905-2419		julianne.marrion@aecom.com

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: NO2, NO3, SO4, Cl	TN, Ammonia	Lab Filter Dissolved Fe, Mn	DOC	Lab Filtered Dissolved Arsenic	Methane	TOT N	N-Nitrate
1	1/24/22	1505	Grab	Ground Water	DV-6-67			X				X	X
			Grab	Ground Water									
			Grab	Ground Water									
			Grab	Ground Water									
			Grab	Ground Water									
			Grab	Ground Water									
			Grab	Ground Water									

Container Type:	AC-Air Cassette	AG-Amber Glass	B-BOD Bottle	C-Cubitainer	J-Jar	O-Other	P-Poly	S-Sterile	V-Vial			P	P
Container Volume:	1-100 mL	2-2.5 gal	3-250 mL	4-300 mL	5-500 mL	6-1L	7-VOA	8-2 oz	9-4 oz	10-8 oz	11-Other*	3	3
Preservation Code:	1-Non Preserved	2-HCl	3-H2SO4	4-HNO3	5-NaOH	6-MeOH	7-Na2S2O3	8-ZnAce, NaOH	9-NH4Cl	10-DI H2O	11-Other*	3	1
											Number of Containers per Sample:	1	1

Laboratory Use Only

Cooler Present: YES ○Drop Off
Seals Intact: ○Pickup
Cooler Temperature: 2.1 °C IR

Sampled by : C Hayden

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
C Hayden AECOM 1/24/22 1505	1/24/22 16:25	1/24/22 17:13	1-24-22 1713
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 22A0724

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 12:39 pm, Feb 01, 2022

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0724

SAMPLE RECEIPT

The following samples were received on January 25, 2022 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
22A0724-01	DV-6-33	Ground Water	200.7, 353.2, 4500N
22A0724-02	DV-1-37	Ground Water	200.7, 353.2, 4500N

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0724

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0724

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DV-6-33
Date Sampled: 01/25/22 14:25
Percent Solids: N/A

ESS Laboratory Work Order: 22A0724
ESS Laboratory Sample ID: 22A0724-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	01/26/22 14:56	10	10	DA22615
Manganese	**0.091** (0.020)		200.7		1	KJK	01/26/22 14:56	10	10	DA22615

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DV-6-33
Date Sampled: 01/25/22 14:25
Percent Solids: N/A

ESS Laboratory Work Order: 22A0724
ESS Laboratory Sample ID: 22A0724-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**8.72** (0.210)		353.2		10	JLK	01/25/22 20:59	mg/L	[CALC]
Total Nitrogen	**8.72** (0.200)		4500N		10	EEM	01/28/22 15:19	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DV-1-37
Date Sampled: 01/25/22 15:30
Percent Solids: N/A

ESS Laboratory Work Order: 22A0724
ESS Laboratory Sample ID: 22A0724-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	01/26/22 14:58	10	10	DA22615
Manganese	**0.025** (0.020)		200.7		1	KJK	01/26/22 14:58	10	10	DA22615

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DV-1-37
Date Sampled: 01/25/22 15:30
Percent Solids: N/A

ESS Laboratory Work Order: 22A0724
ESS Laboratory Sample ID: 22A0724-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**0.813** (0.0300)		353.2		1	JLK	01/25/22 20:53	mg/L	[CALC]
Total Nitrogen	**1.21** (0.200)		4500N		1	EEM	01/28/22 15:20	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0724

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DA22615 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.50		mg/L	2.500		100	80-120			
Manganese	0.504		mg/L	0.5000		101	80-120			
Classical Chemistry										
Batch DA22531 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.257		mg/L	0.2497		103	90-110			
Batch DA22532 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.518		mg/L	0.5000		104	90-110			
Nitrate/Nitrite as N	0.518		mg/L	0.5000		104	90-110			
Batch DA22716 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	20.6	2.00	mg/L	19.90		104	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0724

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0724

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ESS Courier

ESS Project ID: 22A0724
Date Received: 1/25/2022
Project Due Date: 2/1/2022
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 3.9 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** Yes / No / NA
10. Were any analyses received outside of hold time? Yes / No

11. Any Subcontracting needed? Yes / No
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / No
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA
13. Are the samples properly preserved? Yes / No
    a. If metals preserved upon receipt: Date: Time: By:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

14. Was there a need to contact Project Manager? Yes / No
    a. Was there a need to contact the client? Yes / No
    Who was contacted? Date: Time: By:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	253052	Yes	N/A	Yes	250 mL Poly	NP	
1	253053	Yes	N/A	Yes	250 mL Poly	NP	
1	253056	Yes	N/A	Yes	250 mL Poly	H2SO4	
2	253054	Yes	N/A	Yes	250 mL Poly	NP	
2	253055	Yes	N/A	Yes	250 mL Poly	NP	
2	253057	Yes	N/A	Yes	250 mL Poly	H2SO4	

2nd Review
Initials KC
Were all containers scanned into storage/lab? Yes / No
Are barcode labels on correct containers? Yes / No / NA
Are all Flashpoint stickers attached/container ID # circled? Yes / No / NA
Are all Hex Chrome stickers attached? Yes / No / NA
Are all QC stickers attached? Yes / No / NA
Are VOA stickers attached if bubbles noted? Yes / No / NA

Completed By: Date & Time: 1-25-22 1806

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

ESS Project ID: 22A0724

Date Received: 1/25/2022

Reviewed By: Taylor Davis

Date & Time: 1/25/22 1809

ESS Laboratory
Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 22A0724

Turn Time	5	Days
Regulatory State	Massachusetts	
Is this project for any of the following?:	○CT RCP ○MA MCP ○RGP	

Reporting Limits

Electonic Deliverables ☐Data Checker ☐Excel ☐Other (Please Specify →)

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB

Contact Person	Address
Julianne Marrion	250 Apollo Dr

City	State	Zip Code	PO #
Chelmsford	MA	01824	

Telephone Number	FAX Number	Email Address
978-905-2419		julianne.marrion@aecom.com

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: NO2, NO3, SO4, Cl	TN, Ammonia	Lab Filter Dissolved Fe, Mn	DOC	Lab Filtered Dissolved Arsenic	Methane	Total Nitrate
1	1/25/22	1425	Grab	Ground Water	DV-6-33			X				X X
2	1/25/22	1530	Grab	Ground Water	DV-1-37			X				X X
			Grab	Ground Water								
			Grab	Ground Water								
			Grab	Ground Water								
			Grab	Ground Water								
			Grab	Ground Water								
Container Type: AC-Air Cassette AG-Amber Glass B-BOD Bottle C-Cubitainer J-Jar O-Other P-Poly S-Sterile V-Vial								P	AG			P P
Container Volume: 1-100 mL 2-2.5 gal 3-250 mL 4-300 mL 5-500 mL 6-1L 7-VOA 8-2 oz 9-4 oz 10-8 oz 11-Other*								3	G			3 3
Preservation Code: 1-Non Preserved 2-HCl 3-H2SO4 4-HNO3 5-NaOH 6-MeOH 7-Na2S2O3 8-ZnAce, NaOH 9-NH4Cl 10-DI H2O 11-Other*								1	1			3 1
Number of Containers per Sample:								1	0			1 1

Laboratory Use Only

Cooler Present: Yes ○Drop Off
Seals Intact: ○Pickup
Cooler Temperature: 3.9 °C IR

Sampled by : C. Hayden

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
C. Hayden AECOM 1/25/22 1705	1/25/22 17:05	1/25/22 17:58	1/25-22 1758
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 22A0769

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 3:53 pm, Feb 03, 2022

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0769

SAMPLE RECEIPT

The following samples were received on January 26, 2022 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
22A0769-01	NA-1-78	Ground Water	200.7, 353.2, 4500N
22A0769-02	RI-2-44	Ground Water	200.7, 353.2, 4500N

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0769

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0769

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: NA-1-78
Date Sampled: 01/26/22 09:50
Percent Solids: N/A

ESS Laboratory Work Order: 22A0769
ESS Laboratory Sample ID: 22A0769-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	01/27/22 12:03	10	10	DA22615
Manganese	ND (0.020)		200.7		1	KJK	01/27/22 12:03	10	10	DA22615

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: NA-1-78
Date Sampled: 01/26/22 09:50
Percent Solids: N/A

ESS Laboratory Work Order: 22A0769
ESS Laboratory Sample ID: 22A0769-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**1.71** (0.110)		353.2		5	JLK	01/26/22 21:04	mg/L	[CALC]
Total Nitrogen	**1.93** (0.200)		4500N		5	EEM	01/28/22 15:21	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: RI-2-44
Date Sampled: 01/26/22 10:55
Percent Solids: N/A

ESS Laboratory Work Order: 22A0769
ESS Laboratory Sample ID: 22A0769-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	01/27/22 12:12	10	10	DA22615
Manganese	ND (0.020)		200.7		1	KJK	01/27/22 12:12	10	10	DA22615

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: RI-2-44
Date Sampled: 01/26/22 10:55
Percent Solids: N/A

ESS Laboratory Work Order: 22A0769
ESS Laboratory Sample ID: 22A0769-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**1.34** (0.110)		353.2		5	JLK	01/26/22 21:05	mg/L	[CALC]
Total Nitrogen	**1.34** (0.200)		4500N		5	EEM	01/28/22 15:21	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0769

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DA22615 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.50		mg/L	2.500		100	80-120			
Manganese	0.504		mg/L	0.5000		101	80-120			
Classical Chemistry										
Batch DA22649 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.257		mg/L	0.2497		103	90-110			
Batch DA22650 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.498		mg/L	0.5000		100	90-110			
Nitrate/Nitrite as N	0.498		mg/L	0.5000		100	90-110			
Batch DA22716 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	20.6	2.00	mg/L	19.90		104	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0769

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0769

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ESS Courier

ESS Project ID: 22A0769
Date Received: 1/26/2022
Project Due Date: 2/2/2022
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 5.1 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** (Yes) / No / NA
10. Were any analyses received outside of hold time? Yes / (No)

11. Any Subcontracting needed? Yes / (No)
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes (No)
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA

13. Are the samples properly preserved? (Yes) / No
    a. If metals preserved upon receipt: Date: Time: By:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

14. Was there a need to contact Project Manager? Yes / (No)
    a. Was there a need to contact the client? Yes / (No)
    Who was contacted? Date: Time: By:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	253313	Yes	N/A	Yes	250 mL Poly	H2SO4	
1	253315	Yes	N/A	Yes	250 mL Poly	NP	
1	253317	Yes	N/A	Yes	250 mL Poly	NP	
2	253314	Yes	N/A	Yes	250 mL Poly	H2SO4	
2	253316	Yes	N/A	Yes	250 mL Poly	NP	
2	253318	Yes	N/A	Yes	250 mL Poly	NP	

2nd Review
Were all containers scanned into storage/lab? Initials
Are barcode labels on correct containers? (Yes) / No
Are all Flashpoint stickers attached/container ID # circled? Yes / No / (NA)
Are all Hex Chrome stickers attached? Yes / No / (NA)
Are all QC stickers attached? Yes / No / (NA)
Are VOA stickers attached if bubbles noted? Yes / No / (NA)

Completed By: Date & Time: 1/26/22 1032

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

ESS Project ID: 22A0769

Date Received: 1/26/2022

Reviewed By: [signature]

Date & Time: 1/26/22 1646

ESS Laboratory
Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 22A0769

Turn Time	5	Days
Regulatory State	Massachusetts	
Is this project for any of the following?:	○CT RCP ○MA MCP ○RGP	

Reporting Limits

Electonic Deliverables ☐Data Checker ☐Excel ☐Other (Please Specify →)

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB

Contact Person	Address
Julianne Marrion	250 Apollo Dr

City	State	Zip Code	PO #
Chelmsford	MA	01824	

Telephone Number	FAX Number	Email Address
978-905-2419		julianne.marrion@aecom.com

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: NO2, NO3, SO4, Cl	TN, Ammonia	Lab Filter Dissolved Fe, Mn	DOC	Lab Filtered Dissolved Arsenic	Methane	Tot N	NH3N
1	1/26/22	0950	Grab	Ground Water	NA-1-78			X				X	X
2	1/26/22	1055	Grab	Ground Water	RI-2-44			X				X	X
			Grab	Ground Water									
			Grab	Ground Water									
			Grab	Ground Water									
			Grab	Ground Water									
			Grab	Ground Water									
Container Type: AC-Air Cassette AG-Amber Glass B-BOD Bottle C-Cubitainer J-Jar O-Other P-Poly S-Sterile V-Vial								P	AG			P	P
Container Volume: 1-100 mL 2-2.5 gal 3-250 mL 4-300 mL 5-500 mL 6-1L 7-VOA 8-2 oz 9-4 oz 10-8 oz 11-Other*								3	6			3	3
Preservation Code: 1-Non Preserved 2-HCl 3-H2SO4 4-HNO3 5-NaOH 6-MeOH 7-Na2S2O3 8-ZnAce, NaOH 9-NH4Cl 10-DI H2O 11-Other*								1	1			3	1
Number of Containers per Sample:								2	0			2	2

Laboratory Use Only

Cooler Present: Yes ○Drop Off
Seals Intact: ○Pickup
Cooler Temperature: 5.1 °C IR

Sampled by :

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
C Hanyan 1/26/22 1450	1/26/22 14:34	1/26/22 15:58	Taylor Dawes 1558 1/26/22
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 22A0844

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 4:45 pm, Feb 07, 2022

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0844

SAMPLE RECEIPT

The following samples were received on January 27, 2022 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
22A0844-01	BR-3-80	Ground Water	200.7, 353.2, 4500N
22A0844-02	BR-3-60	Ground Water	200.7, 353.2, 4500N
22A0844-03	BR-2-36	Ground Water	200.7, 353.2, 4500N
22A0844-04	BR-2-66	Ground Water	200.7, 353.2, 4500N
22A0844-05	BR-1-55	Ground Water	200.7, 353.2, 4500N
22A0844-06	BR-1-77	Ground Water	200.7, 353.2, 4500N, 5310B
22A0844-07	BR-6-56	Ground Water	200.7, 353.2, 4500N

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0844

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0844

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-3-80
Date Sampled: 01/27/22 12:05
Percent Solids: N/A

ESS Laboratory Work Order: 22A0844
ESS Laboratory Sample ID: 22A0844-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	01/28/22 17:58	10	10	DA22823
Manganese	**0.152** (0.020)		200.7		1	KJK	01/28/22 17:58	10	10	DA22823

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-3-80
Date Sampled: 01/27/22 12:05
Percent Solids: N/A

ESS Laboratory Work Order: 22A0844
ESS Laboratory Sample ID: 22A0844-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**0.620** (0.0300)		353.2		1	JLK	01/27/22 22:11	mg/L	[CALC]
Total Nitrogen	**0.620** (0.200)		4500N		1	JLK	02/02/22 17:28	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-3-60
Date Sampled: 01/27/22 12:08
Percent Solids: N/A

ESS Laboratory Work Order: 22A0844
ESS Laboratory Sample ID: 22A0844-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.465** (0.100)		200.7		1	KJK	01/28/22 18:00	10	10	DA22823
Manganese	ND (0.020)		200.7		1	KJK	01/28/22 18:00	10	10	DA22823

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-3-60
Date Sampled: 01/27/22 12:08
Percent Solids: N/A

ESS Laboratory Work Order: 22A0844
ESS Laboratory Sample ID: 22A0844-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**0.646** (0.0300)		353.2		1	JLK	01/27/22 22:12	mg/L	[CALC]
Total Nitrogen	**0.861** (0.200)		4500N		1	JLK	02/02/22 17:29	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-2-36
Date Sampled: 01/27/22 13:15
Percent Solids: N/A

ESS Laboratory Work Order: 22A0844
ESS Laboratory Sample ID: 22A0844-03
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	01/28/22 18:02	10	10	DA22823
Manganese	ND (0.020)		200.7		1	KJK	01/28/22 18:02	10	10	DA22823

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-2-36
Date Sampled: 01/27/22 13:15
Percent Solids: N/A

ESS Laboratory Work Order: 22A0844
ESS Laboratory Sample ID: 22A0844-03
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**1.06** (0.0500)		353.2		2	JLK	01/27/22 22:38	mg/L	[CALC]
Total Nitrogen	**1.06** (0.200)		4500N		2	JLK	02/02/22 17:30	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-2-66
Date Sampled: 01/27/22 13:55
Percent Solids: N/A

ESS Laboratory Work Order: 22A0844
ESS Laboratory Sample ID: 22A0844-04
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.150** (0.100)		200.7		1	KJK	01/28/22 18:04	10	10	DA22823
Manganese	**0.053** (0.020)		200.7		1	KJK	01/28/22 18:04	10	10	DA22823

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-2-66
Date Sampled: 01/27/22 13:55
Percent Solids: N/A

ESS Laboratory Work Order: 22A0844
ESS Laboratory Sample ID: 22A0844-04
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**0.807** (0.0300)		353.2		1	JLK	01/27/22 22:13	mg/L	[CALC]
Total Nitrogen	**0.807** (0.200)		4500N		1	JLK	02/02/22 17:30	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-1-55
Date Sampled: 01/27/22 14:50
Percent Solids: N/A

ESS Laboratory Work Order: 22A0844
ESS Laboratory Sample ID: 22A0844-05
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	01/28/22 18:07	10	10	DA22823
Manganese	**0.025** (0.020)		200.7		1	KJK	01/28/22 18:07	10	10	DA22823

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-1-55
Date Sampled: 01/27/22 14:50
Percent Solids: N/A

ESS Laboratory Work Order: 22A0844
ESS Laboratory Sample ID: 22A0844-05
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**0.806** (0.0300)		353.2		1	JLK	01/27/22 22:14	mg/L	[CALC]
Total Nitrogen	**0.806** (0.200)		4500N		1	JLK	02/02/22 17:37	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-1-77
Date Sampled: 01/27/22 14:55
Percent Solids: N/A

ESS Laboratory Work Order: 22A0844
ESS Laboratory Sample ID: 22A0844-06
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.155** (0.100)		200.7		1	KJK	01/28/22 18:09	10	10	DA22823
Manganese	**0.068** (0.020)		200.7		1	KJK	01/28/22 18:09	10	10	DA22823

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-1-77
Date Sampled: 01/27/22 14:55
Percent Solids: N/A

ESS Laboratory Work Order: 22A0844
ESS Laboratory Sample ID: 22A0844-06
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.47** (0.500)		5310B		1	CCP	01/31/22 22:11	mg/L	[CALC]
Nitrate as N	**1.31** (0.110)		353.2		5	JLK	01/27/22 22:39	mg/L	[CALC]
Total Nitrogen	**1.31** (0.200)		4500N		5	JLK	02/02/22 17:38	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-6-56
Date Sampled: 01/27/22 15:55
Percent Solids: N/A

ESS Laboratory Work Order: 22A0844
ESS Laboratory Sample ID: 22A0844-07
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	01/28/22 18:11	10	10	DA22823
Manganese	ND (0.020)		200.7		1	KJK	01/28/22 18:11	10	10	DA22823

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-6-56
Date Sampled: 01/27/22 15:55
Percent Solids: N/A

ESS Laboratory Work Order: 22A0844
ESS Laboratory Sample ID: 22A0844-07
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**1.86** (0.110)		353.2		5	JLK	01/27/22 22:40	mg/L	[CALC]
Total Nitrogen	**2.11** (0.200)		4500N		5	JLK	02/02/22 17:38	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0844

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DA22823 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.49		mg/L	2.500		99	80-120			
Manganese	0.508		mg/L	0.5000		102	80-120			
Classical Chemistry										
Batch DA22746 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.257		mg/L	0.2497		103	90-110			
Batch DA22747 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.460		mg/L	0.5000		92	90-110			
Nitrate/Nitrite as N	0.460		mg/L	0.5000		92	90-110			
Batch DA23143 - General Preparation										
Blank										
Dissolved Organic Carbon (1)	ND	0.500	mg/L							
Dissolved Organic Carbon (2)	ND	0.500	mg/L							
LCS										
Dissolved Organic Carbon (1)	4.75	0.500	mg/L	5.000		95	80-120			
Dissolved Organic Carbon (2)	4.82	0.500	mg/L	5.000		96	80-120			
LCS Dup										
Dissolved Organic Carbon (1)	4.99	0.500	mg/L	5.000		100	80-120	5	20	
Dissolved Organic Carbon (2)	4.96	0.500	mg/L	5.000		99	80-120	3	20	
Batch DB20122 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	22.5	2.00	mg/L	19.90		113	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0844

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22A0844

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ESS Courier

ESS Project ID: 22A0844
Date Received: 1/27/2022
Project Due Date: 2/3/2022
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 4.7 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? ~~Yes~~ No mlh 1/31/22
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** Yes / No / NA
10. Were any analyses received outside of hold time? Yes / No

11. Any Subcontracting needed? Yes / (No)
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / (No)
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA
13. Are the samples properly preserved? (Yes) / No
    a. If metals preserved upon receipt: Date: Time: By:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

No tests marked for Sample 7. Reid bottles consistent with other samples

14. Was there a need to contact Project Manager? (Yes) / No mlh 1/31/22
    a. Was there a need to contact the client? Yes / No
    Who was contacted? Chris Hayden Date: 1/28/22 Time: 1725 By: ML

Sample 07 needs sames tests as other samples (sans DOC)

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	253802	Yes	N/A	Yes	250 mL Poly	NP	
1	253803	Yes	N/A	Yes	250 mL Poly	NP	
1	253814	Yes	N/A	Yes	250 mL Poly	H2SO4	
2	253804	Yes	N/A	Yes	250 mL Poly	NP	
2	253805	Yes	N/A	Yes	250 mL Poly	NP	
2	253815	Yes	N/A	Yes	250 mL Poly	H2SO4	
3	253806	Yes	N/A	Yes	250 mL Poly	NP	
3	253807	Yes	N/A	Yes	250 mL Poly	NP	
3	253816	Yes	N/A	Yes	250 mL Poly	H2SO4	
4	253808	Yes	N/A	Yes	250 mL Poly	NP	
4	253809	Yes	N/A	Yes	250 mL Poly	NP	
4	253817	Yes	N/A	Yes	250 mL Poly	H2SO4	
5	253810	Yes	N/A	Yes	250 mL Poly	NP	
5	253811	Yes	N/A	Yes	250 mL Poly	NP	
5	253818	Yes	N/A	Yes	250 mL Poly	H2SO4	
6	253812	Yes	N/A	Yes	250 mL Poly	NP	

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

ESS Project ID: 22A0844

Date Received: 1/27/2022

6	253813	Yes	N/A	Yes	250 mL Poly	NP
6	253819	Yes	N/A	Yes	250 mL Poly	H2SO4
6	253820	Yes	N/A	Yes	1L Amber	NP
7	253893	Yes	N/A	Yes	250 mL Poly	NP
7	253894	Yes	N/A	Yes	250 mL Poly	NP
7	253895	Yes	N/A	Yes	250 mL Poly	H2SO4

2nd Review

Were all containers scanned into storage/lab? Initials KL

Are barcode labels on correct containers? Yes / No

Are all Flashpoint stickers attached/container ID # circled? Yes / No / NA

Are all Hex Chrome stickers attached? Yes / No / NA

Are all QC stickers attached? Yes / No / NA

Are VOA stickers attached if bubbles noted? Yes / No / NA

Completed By: KZ Date & Time: 1.27.22 1903

Reviewed By: [signature] Date & Time: 1/27/22 1908

ESS Laboratory
Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 22A0844

Turn Time: 5 Days
Regulatory State: Massachusetts
Is this project for any of the following?: ○CT RCP ○MA MCP ○RGP
Reporting Limits:
Electonic Deliverables: ☐Data Checker ☐Excel ☐Other (Please Specify →)

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB

Contact Person	Address		
Julianne Marrion	250 Apollo Dr		
City	**State**	**Zip Code**	**PO #**
Chelmsford	MA	01824	
Telephone Number	**FAX Number**	**Email Address**	
978-905-2419		julianne.marrion@aecom.com	

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: NO2, NO3, SO4, Cl	TN, Ammonia	Lab Filter Dissolved Fe, Mn	DOC	Lab Filtered Dissolved Arsenic	Methane	TKN	NH3-N
1	1/27/22	1205	Grab	Ground Water	BR-3-80			X				X	X
2		1258	Grab	Ground Water	BR-3-60			X				X	X
3		1316	Grab	Ground Water	BR-2-86			X				X	X
4		1355	Grab	Ground Water	BR-2-46			X				X	X
5		1450	Grab	Ground Water	BR-1-55			X				X	X
6		1455	Grab	Ground Water	BR-1-77			X	X			X	X
7	↓	1555	Grab	Ground Water	BR-6-56			X				X	X
					ML -1/31/22								
Container Type:					AC-Air Cassette AG-Amber Glass B-BOD Bottle C-Cubitainer J-Jar O-Other P-Poly S-Sterile V-Vial			P	AG			P	P
Container Volume:					1-100 mL 2-2.5 gal 3-250 mL 4-300 mL 5-500 mL 6-1L 7-VOA 8-2 oz 9-4 oz 10-8 oz 11-Other*			3	6			3	3
Preservation Code:					1-Non Preserved 2-HCl 3-H2SO4 4-HNO3 5-NaOH 6-MeOH 7-Na2S2O3 8-ZnAce, NaOH 9-NH4Cl 10-DI H2O 11-Other*			1	1			3	1
					Number of Containers per Sample:			1	1			1	1

Laboratory Use Only
Cooler Present: Yes ○Drop Off
Seals Intact: ○Pickup
Cooler Temperature: 1.7 °C IC

Sampled by : CHayden

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
1/27/22 1645	1/27/22 16:45	1/27/22 18:24	1-27-22 18:24
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 22B0131

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 4:29 pm, Feb 10, 2022

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22B0131

SAMPLE RECEIPT

The following samples were received on February 03, 2022 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
22B0131-01	BR-4-84	Ground Water	200.7, 353.2, 4500N
22B0131-02	BR-4-68	Ground Water	200.7, 353.2, 4500N
22B0131-03	BR-5-64	Ground Water	200.7, 353.2, 4500N
22B0131-04	BR-5-37	Ground Water	200.7, 353.2, 4500N
22B0131-05	NA-2-55	Ground Water	200.7, 353.2, 4500N, 5310B
22B0131-06	NA-2-22	Ground Water	200.7, 353.2, 4500N
22B0131-07	RI-3-77	Ground Water	200.7, 353.2, 4500N

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22B0131

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22B0131

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-4-84
Date Sampled: 02/03/22 11:20
Percent Solids: N/A

ESS Laboratory Work Order: 22B0131
ESS Laboratory Sample ID: 22B0131-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.181** (0.100)		200.7		1	KJK	02/08/22 18:54	10	10	DB20831
Manganese	**0.183** (0.020)		200.7		1	KJK	02/08/22 18:54	10	10	DB20831

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-4-84
Date Sampled: 02/03/22 11:20
Percent Solids: N/A

ESS Laboratory Work Order: 22B0131
ESS Laboratory Sample ID: 22B0131-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**2.60** (0.110)		353.2		5	JLK	02/03/22 22:13	mg/L	[CALC]
Total Nitrogen	**2.62** (0.200)		4500N		5	JLK	02/07/22 16:47	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-4-68
Date Sampled: 02/03/22 11:17
Percent Solids: N/A

ESS Laboratory Work Order: 22B0131
ESS Laboratory Sample ID: 22B0131-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.223** (0.100)		200.7		1	KJK	02/08/22 19:03	10	10	DB20831
Manganese	**0.045** (0.020)		200.7		1	KJK	02/08/22 19:03	10	10	DB20831

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-4-68
Date Sampled: 02/03/22 11:17
Percent Solids: N/A

ESS Laboratory Work Order: 22B0131
ESS Laboratory Sample ID: 22B0131-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**0.435** (0.0300)		353.2		1	JLK	02/03/22 21:58	mg/L	[CALC]
Total Nitrogen	**0.824** (0.200)		4500N		1	JLK	02/07/22 16:48	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-5-64
Date Sampled: 02/03/22 12:40
Percent Solids: N/A

ESS Laboratory Work Order: 22B0131
ESS Laboratory Sample ID: 22B0131-03
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.133** (0.100)		200.7		1	KJK	02/08/22 19:05	10	10	DB20831
Manganese	**0.044** (0.020)		200.7		1	KJK	02/08/22 19:05	10	10	DB20831

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-5-64
Date Sampled: 02/03/22 12:40
Percent Solids: N/A

ESS Laboratory Work Order: 22B0131
ESS Laboratory Sample ID: 22B0131-03
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**1.09** (0.0500)		353.2		2	JLK	02/03/22 22:14	mg/L	[CALC]
Total Nitrogen	**1.45** (0.200)		4500N		2	JLK	02/07/22 16:49	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-5-37
Date Sampled: 02/03/22 12:35
Percent Solids: N/A

ESS Laboratory Work Order: 22B0131
ESS Laboratory Sample ID: 22B0131-04
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	02/08/22 19:07	10	10	DB20831
Manganese	**0.449** (0.020)		200.7		1	KJK	02/08/22 19:07	10	10	DB20831

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-5-37
Date Sampled: 02/03/22 12:35
Percent Solids: N/A

ESS Laboratory Work Order: 22B0131
ESS Laboratory Sample ID: 22B0131-04
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**1.07** (0.0500)		353.2		2	JLK	02/03/22 22:15	mg/L	[CALC]
Total Nitrogen	**1.43** (0.200)		4500N		2	JLK	02/07/22 16:50	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: NA-2-55
Date Sampled: 02/03/22 14:30
Percent Solids: N/A

ESS Laboratory Work Order: 22B0131
ESS Laboratory Sample ID: 22B0131-05
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**1.17** (0.100)		200.7		1	KJK	02/08/22 19:10	10	10	DB20831
Manganese	**1.38** (0.020)		200.7		1	KJK	02/08/22 19:10	10	10	DB20831

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: NA-2-55
Date Sampled: 02/03/22 14:30
Percent Solids: N/A

ESS Laboratory Work Order: 22B0131
ESS Laboratory Sample ID: 22B0131-05
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.00** (0.500)		5310B		1	CCP	02/07/22 21:13	mg/L	[CALC]
Nitrate as N	ND (0.0300)		353.2		1	JLK	02/03/22 22:01	mg/L	[CALC]
Total Nitrogen	**0.695** (0.200)		4500N		1	JLK	02/07/22 16:50	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: NA-2-22
Date Sampled: 02/03/22 14:10
Percent Solids: N/A

ESS Laboratory Work Order: 22B0131
ESS Laboratory Sample ID: 22B0131-06
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**3.00** (0.100)		200.7		1	KJK	02/08/22 19:12	10	10	DB20831
Manganese	**0.096** (0.020)		200.7		1	KJK	02/08/22 19:12	10	10	DB20831

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: NA-2-22
Date Sampled: 02/03/22 14:10
Percent Solids: N/A

ESS Laboratory Work Order: 22B0131
ESS Laboratory Sample ID: 22B0131-06
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	ND (0.0300)		353.2		1	JLK	02/03/22 22:02	mg/L	[CALC]
Total Nitrogen	**0.758** (0.200)		4500N		1	JLK	02/07/22 16:51	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: RI-3-77
Date Sampled: 02/03/22 15:30
Percent Solids: N/A

ESS Laboratory Work Order: 22B0131
ESS Laboratory Sample ID: 22B0131-07
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	02/08/22 19:14	10	10	DB20831
Manganese	**0.058** (0.020)		200.7		1	KJK	02/08/22 19:14	10	10	DB20831

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: RI-3-77
Date Sampled: 02/03/22 15:30
Percent Solids: N/A

ESS Laboratory Work Order: 22B0131
ESS Laboratory Sample ID: 22B0131-07
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Nitrate as N	**1.14** (0.0500)		353.2		2	JLK	02/03/22 22:16	mg/L	[CALC]
Total Nitrogen	**1.34** (0.200)		4500N		2	JLK	02/07/22 16:52	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22B0131

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DB20831 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.54		mg/L	2.500		102	80-120			
Manganese	0.510		mg/L	0.5000		102	80-120			
Classical Chemistry										
Batch DB20331 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.255		mg/L	0.2497		102	90-110			
Batch DB20332 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.538		mg/L	0.5000		108	90-110			
Nitrate/Nitrite as N	0.538		mg/L	0.5000		108	90-110			
Batch DB20422 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	22.3	2.00	mg/L	19.90		112	80-120			
Batch DB20748 - General Preparation										
Blank										
Dissolved Organic Carbon (1)	ND	0.500	mg/L							
Dissolved Organic Carbon (2)	ND	0.500	mg/L							
LCS										
Dissolved Organic Carbon (1)	4.86	0.500	mg/L	5.000		97	80-120			
Dissolved Organic Carbon (2)	4.94	0.500	mg/L	5.000		99	80-120			
LCS Dup										
Dissolved Organic Carbon (1)	4.79	0.500	mg/L	5.000		96	80-120	2	20	
Dissolved Organic Carbon (2)	4.78	0.500	mg/L	5.000		96	80-120	3	20	

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22B0131

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22B0131

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ESS Courier

ESS Project ID: 22B0131
Date Received: 2/3/2022
Project Due Date: 2/10/2022
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 3.2 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? ~~Yes~~ No
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** (Yes) / No / NA
10. Were any analyses received outside of hold time? Yes / (No)

11. Any Subcontracting needed? Yes / (No)
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / (No)
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA

13. Are the samples properly preserved? (Yes) / No
    a. If metals preserved upon receipt: Date: Time: By:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

Samples 1+2 times are swapped on bottles when comparing it to the COC

14. Was there a need to contact Project Manager? (Yes) / No
    a. Was there a need to contact the client? Yes / No
    Who was contacted? Juli Marrion Date: 2/4/22 Time: By: ML

Sample jars are correct. COC corrected

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	255004	Yes	N/A	Yes	250 mL Poly	NP	
1	255005	Yes	N/A	Yes	250 mL Poly	NP	
1	255018	Yes	N/A	Yes	250 mL Poly	H2SO4	
2	255006	Yes	N/A	Yes	250 mL Poly	NP	
2	255007	Yes	N/A	Yes	250 mL Poly	NP	
2	255019	Yes	N/A	Yes	250 mL Poly	H2SO4	
3	255008	Yes	N/A	Yes	250 mL Poly	NP	
3	255009	Yes	N/A	Yes	250 mL Poly	NP	
3	255020	Yes	N/A	Yes	250 mL Poly	H2SO4	
4	255010	Yes	N/A	Yes	250 mL Poly	NP	
4	255011	Yes	N/A	Yes	250 mL Poly	NP	
4	255021	Yes	N/A	Yes	250 mL Poly	H2SO4	
5	255012	Yes	N/A	Yes	250 mL Poly	NP	
5	255013	Yes	N/A	Yes	250 mL Poly	NP	
5	255022	Yes	N/A	Yes	250 mL Poly	H2SO4	
5	255025	Yes	N/A	Yes	1L Amber	NP	

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

ESS Project ID: 22B0131
Date Received: 2/3/2022

6	255014	Yes	N/A	Yes	250 mL Poly	NP
6	255015	Yes	N/A	Yes	250 mL Poly	NP
6	255023	Yes	N/A	Yes	250 mL Poly	H2SO4
7	255016	Yes	N/A	Yes	250 mL Poly	NP
7	255017	Yes	N/A	Yes	250 mL Poly	NP
7	255024	Yes	N/A	Yes	250 mL Poly	H2SO4

2nd Review

Were all containers scanned into storage/lab? Initials

Are barcode labels on correct containers? Yes / No

Are all Flashpoint stickers attached/container ID # circled? Yes / No / NA

Are all Hex Chrome stickers attached? Yes / No / NA

Are all QC stickers attached? Yes / No / NA

Are VOA stickers attached if bubbles noted? Yes / No / NA

Completed By: Date & Time: 1812 2/3/22

Reviewed By: Date & Time: 2/3/22 1821

ML - 2/4/22

TD 2/3/22

ESS Laboratory
Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # ~~22B00~~ 22B0131

Reporting Limits

Electonic Deliverables ☐ Data Checker ☐ Excel ☐ Other (Please Specify →)

Turn Time	5	Days
Regulatory State	Massachusetts	
Is this project for any of the following?:	○CT RCP ○MA MCP ○RGP	

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB

Contact Person	Address
Julianne Marrion	250 Apollo Dr

City	State	Zip Code	PO #
Chelmsford	MA	01824	

Telephone Number	FAX Number	Email Address
978-905-2419		julianne.marrion@aecom.com

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: NO2, NO3, SO4, Cl	TN, Ammonia	Lab Filter Dissolved Fe, Mn	DOC	Lab Filtered Dissolved Arsenic	Methane	TKN	Nitrate-N
1	2/3/22	~~1117~~	1120 Grab	Ground Water	BR-21-84			X				X	X
2	↓	~~1120~~	1117 Grab	Ground Water	BR-21-68			X				X	X
3		1240	Grab	Ground Water	BR-5-64			X				X	X
4		1235	Grab	Ground Water	BR-5-37			X				X	X
5		1430	Grab	Ground Water	NA-2-55			X	X			X	X
6		1410	Grab	Ground Water	NA-2-22			X				X	X
7		1530	Grab	Ground Water	RI-3-77			X				X	X

Container Type: AC-Air Cassette AG-Amber Glass B-BOD Bottle C-Cubitainer J-Jar O-Other P-Poly S-Sterile V-Vial

Container Volume: 1-100 mL 2-2.5 gal 3-250 mL 4-300 mL 5-500 mL 6-1L 7-VOA 8-2 oz 9-4 oz 10-8 oz 11-Other*

Preservation Code: 1-Non Preserved 2-HCl 3-H2SO4 4-HNO3 5-NaOH 6-MeOH 7-Na2S2O3 8-ZnAce, NaOH 9-NH4Cl 10-DI H2O 11-Other*

Number of Containers per Sample:								
			P	AG			P	P
			3	C			3	3
			1	1			3	1
			1	1			1	1

Laboratory Use Only

Cooler Present: Yes ○Drop Off

Seals Intact: ○Pickup

Cooler Temperature: 3.2 °C / Ice

Sampled by : B. Young

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
2-3-22 1635	2/3/22 16:35	2/3/22 18:00	Taylor Davies 2/3/22 1800
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 22E0314

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 7:31 pm, May 18, 2022

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0314

SAMPLE RECEIPT

The following samples were received on May 10, 2022 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
22E0314-01	NA-1-78	Ground Water	200.7, 353.2, 4500N, 5310B
22E0314-02	NA-1-92	Ground Water	200.7, 353.2, 4500N, 5310B
22E0314-03	RI-2-44	Ground Water	200.7, 353.2, 4500N, 5310B
22E0314-04	RI-2-58	Ground Water	200.7, 353.2, 4500N, 5310B
22E0314-05	RI-3-77	Ground Water	200.7, 353.2, 4500N, 5310B
22E0314-06	RI-3-90	Ground Water	200.7, 353.2, 4500N, 5310B

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0314

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0314

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: NA-1-78
Date Sampled: 05/09/22 14:20
Percent Solids: N/A

ESS Laboratory Work Order: 22E0314
ESS Laboratory Sample ID: 22E0314-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/14/22 15:53	10	10	DE21146
Manganese	ND (0.020)		200.7		1	KJK	05/12/22 15:58	10	10	DE21146

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: NA-1-78
Date Sampled: 05/09/22 14:20
Percent Solids: N/A

ESS Laboratory Work Order: 22E0314
ESS Laboratory Sample ID: 22E0314-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.650** (0.500)		5310B		1	CCP	05/10/22 22:19	mg/L	[CALC]
Nitrate as N	**1.83** (0.110)		353.2		5	JLK	05/10/22 19:44	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/10/22 18:23	mg/L	DE21030
Total Nitrogen	**1.83** (0.200)		4500N		5	JLK	05/18/22 15:21	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: NA-1-92
Date Sampled: 05/09/22 14:25
Percent Solids: N/A

ESS Laboratory Work Order: 22E0314
ESS Laboratory Sample ID: 22E0314-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/14/22 16:08	10	10	DE21146
Manganese	ND (0.020)		200.7		1	KJK	05/12/22 16:13	10	10	DE21146

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: NA-1-92
Date Sampled: 05/09/22 14:25
Percent Solids: N/A

ESS Laboratory Work Order: 22E0314
ESS Laboratory Sample ID: 22E0314-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.648** (0.500)		5310B		1	CCP	05/11/22 15:08	mg/L	[CALC]
Nitrate as N	**0.739** (0.0300)		353.2		1	JLK	05/10/22 19:21	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/10/22 18:24	mg/L	DE21030
Total Nitrogen	**1.39** (0.200)		4500N		1	JLK	05/18/22 15:21	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: RI-2-44
Date Sampled: 05/09/22 11:50
Percent Solids: N/A

ESS Laboratory Work Order: 22E0314
ESS Laboratory Sample ID: 22E0314-03
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/14/22 16:10	10	10	DE21146
Manganese	**0.028** (0.020)		200.7		1	KJK	05/12/22 16:15	10	10	DE21146

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: RI-2-44
Date Sampled: 05/09/22 11:50
Percent Solids: N/A

ESS Laboratory Work Order: 22E0314
ESS Laboratory Sample ID: 22E0314-03
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	ND (0.500)		5310B		1	CCP	05/11/22 15:20	mg/L	[CALC]
Nitrate as N	**1.13** (0.0500)		353.2		2	JLK	05/10/22 19:45	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/10/22 18:25	mg/L	DE21030
Total Nitrogen	**1.67** (0.200)		4500N		2	JLK	05/18/22 15:22	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: RI-2-58
Date Sampled: 05/09/22 12:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0314
ESS Laboratory Sample ID: 22E0314-04
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**2.16** (0.100)		200.7		1	KJK	05/14/22 16:12	10	10	DE21146
Manganese	**0.419** (0.020)		200.7		1	KJK	05/12/22 16:17	10	10	DE21146

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: RI-2-58
Date Sampled: 05/09/22 12:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0314
ESS Laboratory Sample ID: 22E0314-04
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.751** (0.500)		5310B		1	CCP	05/11/22 15:32	mg/L	[CALC]
Nitrate as N	**0.451** (0.0300)		353.2		1	JLK	05/10/22 19:23	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/10/22 18:26	mg/L	DE21030
Total Nitrogen	**0.882** (0.200)		4500N		1	JLK	05/18/22 15:29	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: RI-3-77
Date Sampled: 05/09/22 13:10
Percent Solids: N/A

ESS Laboratory Work Order: 22E0314
ESS Laboratory Sample ID: 22E0314-05
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/14/22 16:15	10	10	DE21146
Manganese	**0.065** (0.020)		200.7		1	KJK	05/12/22 16:19	10	10	DE21146

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: RI-3-77
Date Sampled: 05/09/22 13:10
Percent Solids: N/A

ESS Laboratory Work Order: 22E0314
ESS Laboratory Sample ID: 22E0314-05
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.776** (0.500)		5310B		1	CCP	05/11/22 15:44	mg/L	[CALC]
Nitrate as N	**0.481** (0.0300)		353.2		1	JLK	05/10/22 19:29	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/10/22 18:32	mg/L	DE21030
Total Nitrogen	**0.481** (0.200)		4500N		1	JLK	05/18/22 15:29	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: RI-3-90
Date Sampled: 05/09/22 13:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0314
ESS Laboratory Sample ID: 22E0314-06
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.157** (0.100)		200.7		1	KJK	05/17/22 18:11	10	10	DE21146
Manganese	**0.105** (0.020)		200.7		1	KJK	05/12/22 16:21	10	10	DE21146

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: RI-3-90
Date Sampled: 05/09/22 13:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0314
ESS Laboratory Sample ID: 22E0314-06
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.690** (0.500)		5310B		1	CCP	05/11/22 15:57	mg/L	[CALC]
Nitrate as N	**1.58** (0.110)		353.2		5	JLK	05/10/22 19:46	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/10/22 18:32	mg/L	DE21030
Total Nitrogen	**1.58** (0.200)		4500N		5	JLK	05/18/22 15:30	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0314

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DE21146 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
Blank										
Iron	ND	0.100	mg/L							
LCS										
Iron	2.54		mg/L	2.500		102	80-120			
Manganese	0.515		mg/L	0.5000		103	80-120			
Classical Chemistry										
Batch DE21030 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.249		mg/L	0.2497		100	90-110			
Nitrite as N	0.249		mg/L	0.2497		100	90-110			
Batch DE21031 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.504		mg/L	0.5000		101	90-110			
Nitrate/Nitrite as N	0.504		mg/L	0.5000		101	90-110			
Batch DE21047 - General Preparation										
Blank										
Dissolved Organic Carbon (1)	ND	0.500	mg/L							
Dissolved Organic Carbon (2)	ND	0.500	mg/L							
LCS										
Dissolved Organic Carbon (1)	4.62	0.500	mg/L	5.000		92	80-120			
Dissolved Organic Carbon (2)	4.75	0.500	mg/L	5.000		95	80-120			
LCS Dup										
Dissolved Organic Carbon (1)	4.66	0.500	mg/L	5.000		93	80-120	0.8	20	
Dissolved Organic Carbon (2)	4.67	0.500	mg/L	5.000		93	80-120	2	20	
Batch DE21737 - General Preparation										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	11.7	2.00	mg/L	13.20		88	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0314

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0314

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ESS Courier

ESS Project ID: 22E0314
Date Received: 5/10/2022
Project Due Date: 5/17/2022
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 4.4 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** (Yes) / No / NA
10. Were any analyses received outside of hold time? Yes / (No)

11. Any Subcontracting needed? (Yes) / No
    ESS Sample IDs: 1-10
    Analysis: TN Nitrogen
    TAT: 5 Day
12. Were VOAs received? Yes / (No)
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA
13. Are the samples properly preserved? (Yes) / No
    a. If metals preserved upon receipt: Date: ____ Time: ____ By/Acid Lot#: ____
    b. Low Level VOA vials frozen: Date: ____ Time: ____ By: ____

Sample Receiving Notes:

14. Was there a need to contact Project Manager? Yes / (No)
    a. Was there a need to contact the client? Yes / (No)
    Who was contacted? ____ Date: ____ Time: ____ By: ____

Resolution:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	289747	Yes	N/A	Yes	1L Poly	H2SO4	
1	289753	Yes	N/A	Yes	250 mL Poly	NP	
1	289759	Yes	N/A	Yes	250 mL Amber	NP	
1	290229	Yes	N/A	Yes	250 mL Poly	NP	
2	289748	Yes	N/A	Yes	1L Poly	H2SO4	
2	289754	Yes	N/A	Yes	250 mL Poly	NP	
2	289760	Yes	N/A	Yes	250 mL Amber	NP	
2	290230	Yes	N/A	Yes	250 mL Poly	NP	
3	289749	Yes	N/A	Yes	1L Poly	H2SO4	
3	289755	Yes	N/A	Yes	250 mL Poly	NP	
3	289761	Yes	N/A	Yes	250 mL Amber	NP	
3	290231	Yes	N/A	Yes	250 mL Poly	NP	
4	289750	Yes	N/A	Yes	1L Poly	H2SO4	
4	289756	Yes	N/A	Yes	250 mL Poly	NP	
4	289762	Yes	N/A	Yes	250 mL Amber	NP	
4	290232	Yes	N/A	Yes	250 mL Poly	NP	
5	289751	Yes	N/A	Yes	1L Poly	H2SO4	

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

ESS Project ID: 22E0314
Date Received: 5/10/2022

5	289757	Yes	N/A	Yes	250 mL Poly	NP
5	289763	Yes	N/A	Yes	250 mL Amber	NP
5	290233	Yes	N/A	Yes	250 mL Poly	NP
6	289752	Yes	N/A	Yes	1L Poly	H2SO4
6	289758	Yes	N/A	Yes	250 mL Poly	NP
6	289764	Yes	N/A	Yes	250 mL Amber	NP
6	290234	Yes	N/A	Yes	250 mL Poly	NP

2nd Review

Were all containers scanned into storage/lab? Initials KL

Are barcode labels on correct containers? (Yes) / No

Are all Flashpoint stickers attached/container ID # circled? Yes / No / NA

Are all Hex Chrome stickers attached? Yes / No / NA

Are all QC stickers attached? Yes / No / NA

Are VOA stickers attached if bubbles noted? Yes / No / NA

Completed By: KL Date & Time: 5.10.22 1702

Reviewed By: Taylor Davis Date & Time: 5/10/22 1718.

ESS Laboratory

Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 22E0314

Turn Time	5	Days
Regulatory State	Massachusetts	
Is this project for any of the following?:	○ CT RCP ○ MA MCP ○ RGP	
Reporting Limits		
Electonic Deliverables	☐ Data Checker ☐ Excel ☐ Other (Please Specify →)	

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB

	Address	
Julianne Marrion	250 Apollo Dr	

City	State	Zip Code	PO #
Chelmsford	MA	01824	

Telephone Number	FAX Number	Email Address
978-905-2419		julianne.marrion@aecom.com

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: Total Nitrogen	Nitrate, Nitrite	Lab Filter Dissolved Fe, Mn	DOC
1	5.9.22	1420	Grab	Ground Water	NA-1-78	X	X	X	X
2	↓	1425	Grab	Ground Water	NA-1-92	X	X	X	X
3		1150	Grab	Ground Water	RI-2-44	X	X	X	X
4		1205	Grab	Ground Water	RI-2-58	X	X	X	X
5		1310	Grab	Ground Water	RI-3-77	X	X	X	X
6	↓	1305	Grab	Ground Water	RI-3-90	X	X	X	X
			Grab	Ground Water					
			Grab	Ground Water					
			Grab	Ground Water					
			Grab	Ground Water					

Container Type:	AC-Air Cassette	AG-Amber Glass	B-BOD Bottle	C-Cubitainer	J-Jar	O-Other	P-Poly	S-Sterile	V-Vial	P	P	P	AG	V
Container Volume:	1-100 mL	2-2.5 gal	3-250 mL	4-300 mL	5-500 mL	6-1L	7-VOA	8-2 oz	9-4 oz	10-8 oz	11-Other*	6	3	3	3	7
Preservation Code:	1-Non Preserved	2-HCl	3-H2SO4	4-HNO3	5-NaOH	6-Methanol	7-Na2S2O3	8-ZnAce, NaOH	9-NH4Cl	10-DI H2O	11-Other*	3	1	1	1	2
											Number of Containers per Sample:	1	1	1	1	2

Laboratory Use Only

Cooler Present: Yes ○ Drop Off
Seals Intact: ○ Pickup
Cooler Temperature: 4.4 °C Ice

Sampled by : C Hayden

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
C Hayden 5.9.22 1615	5/9 16:17	5/10 11:29	5/10/22 11:29
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
5/10/22 16:38	5.10.22 1638		

CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 22E0397

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 3:08 pm, May 19, 2022

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0397

SAMPLE RECEIPT

The following samples were received on May 11, 2022 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
22E0397-01	DU-2-26	Ground Water	200.7, 353.2, 4500N, 5310B
22E0397-02	DU-2-63	Ground Water	200.7, 353.2, 4500N, 5310B
22E0397-03	DU-2-100	Ground Water	200.7, 353.2, 4500N, 5310B
22E0397-04	DU-1-37	Ground Water	200.7, 353.2, 4500N, 5310B
22E0397-05	DU-1-68	Ground Water	200.7, 353.2, 4500N, 5310B
22E0397-06	DU-1-100	Ground Water	200.7, 353.2, 4500N, 5310B
22E0397-07	DU-3-51	Ground Water	200.7, 353.2, 4500N, 5310B
22E0397-08	DU-3-76	Ground Water	200.7, 353.2, 4500N, 5310B
22E0397-09	DU-3-100	Ground Water	200.7, 353.2, 4500N, 5310B

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0397

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0397

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-2-26
Date Sampled: 05/10/22 10:55
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 20:11	10	10	DE21338
Manganese	ND (0.020)		200.7		1	KJK	05/17/22 20:11	10	10	DE21338

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-2-26
Date Sampled: 05/10/22 10:55
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**5.23** (0.500)		5310B		1	CCP	05/12/22 19:53	mg/L	[CALC]
Nitrate as N	**4.15** (0.210)		353.2		10	JLK	05/11/22 20:22	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/11/22 19:20	mg/L	DE21128
Total Nitrogen	**4.65** (0.200)		4500N		10	JLK	05/18/22 15:31	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-2-63
Date Sampled: 05/10/22 10:20
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 20:20	10	10	DE21338
Manganese	**0.049** (0.020)		200.7		1	KJK	05/17/22 20:20	10	10	DE21338

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-2-63
Date Sampled: 05/10/22 10:20
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.794** (0.500)		5310B		1	CCP	05/12/22 20:30	mg/L	[CALC]
Nitrate as N	**1.18** (0.110)		353.2		5	JLK	05/11/22 20:25	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/11/22 19:23	mg/L	DE21128
Total Nitrogen	**1.43** (0.200)		4500N		5	JLK	05/18/22 15:32	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-2-100
Date Sampled: 05/10/22 10:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-03
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**1.09** (0.100)		200.7		1	KJK	05/17/22 20:22	10	10	DE21338
Manganese	**0.433** (0.020)		200.7		1	KJK	05/17/22 20:22	10	10	DE21338

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-2-100
Date Sampled: 05/10/22 10:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-03
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.554** (0.500)		5310B		1	CCP	05/12/22 20:42	mg/L	[CALC]
Nitrate as N	**0.654** (0.0300)		353.2		1	JLK	05/11/22 19:59	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/11/22 19:24	mg/L	DE21128
Total Nitrogen	**0.654** (0.200)		4500N		1	JLK	05/18/22 15:33	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-1-37
Date Sampled: 05/10/22 12:35
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-04
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 20:24	10	10	DE21338
Manganese	**0.038** (0.020)		200.7		1	KJK	05/17/22 20:24	10	10	DE21338

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-1-37
Date Sampled: 05/10/22 12:35
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-04
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**2.13** (0.500)		5310B		1	CCP	05/12/22 20:54	mg/L	[CALC]
Nitrate as N	**0.246** (0.0300)		353.2		1	JLK	05/11/22 20:00	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/11/22 19:25	mg/L	DE21128
Total Nitrogen	**0.483** (0.200)		4500N		1	JLK	05/18/22 15:34	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-1-68
Date Sampled: 05/10/22 11:50
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-05
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 20:27	10	10	DE21338
Manganese	**0.088** (0.020)		200.7		1	KJK	05/17/22 20:27	10	10	DE21338

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-1-68
Date Sampled: 05/10/22 11:50
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-05
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.05** (0.500)		5310B		1	CCP	05/12/22 21:07	mg/L	[CALC]
Nitrate as N	**1.56** (0.110)		353.2		5	JLK	05/11/22 20:26	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/11/22 19:26	mg/L	DE21128
Total Nitrogen	**1.56** (0.200)		4500N		5	JLK	05/18/22 15:34	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-1-100
Date Sampled: 05/10/22 12:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-06
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 20:29	10	10	DE21338
Manganese	**0.199** (0.020)		200.7		1	KJK	05/17/22 20:29	10	10	DE21338

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-1-100
Date Sampled: 05/10/22 12:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-06
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.588** (0.500)		5310B		1	CCP	05/12/22 21:19	mg/L	[CALC]
Nitrate as N	**3.46** (0.210)		353.2		10	JLK	05/11/22 20:27	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/11/22 19:27	mg/L	DE21128
Total Nitrogen	**3.69** (0.200)		4500N		10	JLK	05/18/22 15:35	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-3-51
Date Sampled: 05/10/22 15:00
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-07
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 20:31	10	10	DE21338
Manganese	ND (0.020)		200.7		1	KJK	05/17/22 20:31	10	10	DE21338

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-3-51
Date Sampled: 05/10/22 15:00
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-07
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.83** (0.500)		5310B		1	CCP	05/12/22 21:56	mg/L	[CALC]
Nitrate as N	**0.990** (0.0300)		353.2		1	JLK	05/11/22 20:08	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/11/22 19:33	mg/L	DE21128
Total Nitrogen	**1.30** (0.200)		4500N		1	JLK	05/18/22 15:36	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-3-76
Date Sampled: 05/10/22 13:37
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-08
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.143** (0.100)		200.7		1	KJK	05/17/22 20:33	10	10	DE21338
Manganese	**0.087** (0.020)		200.7		1	KJK	05/17/22 20:33	10	10	DE21338

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-3-76
Date Sampled: 05/10/22 13:37
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-08
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.16** (0.500)		5310B		1	CCP	05/12/22 22:08	mg/L	[CALC]
Nitrate as N	**2.81** (0.110)		353.2		5	JLK	05/11/22 20:29	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/11/22 19:34	mg/L	DE21128
Total Nitrogen	**3.72** (0.200)		4500N		5	JLK	05/18/22 15:43	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-3-100
Date Sampled: 05/10/22 14:15
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-09
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 20:35	10	10	DE21338
Manganese	**0.043** (0.020)		200.7		1	KJK	05/17/22 20:35	10	10	DE21338

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-3-100
Date Sampled: 05/10/22 14:15
Percent Solids: N/A

ESS Laboratory Work Order: 22E0397
ESS Laboratory Sample ID: 22E0397-09
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.974** (0.500)		5310B		1	CCP	05/12/22 22:20	mg/L	[CALC]
Nitrate as N	**2.68** (0.110)		353.2		5	JLK	05/11/22 20:30	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/11/22 19:34	mg/L	DE21128
Total Nitrogen	**2.68** (0.200)		4500N		5	JLK	05/18/22 15:43	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0397

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DE21338 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.52		mg/L	2.500		101	80-120			
Manganese	0.516		mg/L	0.5000		103	80-120			
Classical Chemistry										
Batch DE21128 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.252		mg/L	0.2497		101	90-110			
Nitrite as N	0.252		mg/L	0.2497		101	90-110			
Batch DE21130 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.507		mg/L	0.5000		101	90-110			
Nitrate/Nitrite as N	0.507		mg/L	0.5000		101	90-110			
Batch DE21242 - General Preparation										
Blank										
Dissolved Organic Carbon (1)	ND	0.500	mg/L							
Dissolved Organic Carbon (2)	ND	0.500	mg/L							
LCS										
Dissolved Organic Carbon (1)	5.62	0.500	mg/L	5.000		112	80-120			
Dissolved Organic Carbon (2)	5.72	0.500	mg/L	5.000		114	80-120			
LCS Dup										
Dissolved Organic Carbon (1)	5.68	0.500	mg/L	5.000		114	80-120	1	20	
Dissolved Organic Carbon (2)	5.65	0.500	mg/L	5.000		113	80-120	1	20	
Batch DE21737 - General Preparation										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	11.7	2.00	mg/L	13.20		88	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0397

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0397

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ESS Courier

ESS Project ID: 22E0397
Date Received: 5/11/2022
Project Due Date: 5/18/2022
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 1.9 Iced with: Ice
5. Was COC signed and dated by client? Yes

6. Does COC match bottles? ~~Yes~~ NO (MM 5/11/22)
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** Yes / No / NA
10. Were any analyses received outside of hold time? Yes / No

11. Any Subcontracting needed? Yes / No
    ESS Sample IDs:
    Analysis:
    TAT:

12. Were VOAs received? Yes / No
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA

13. Are the samples properly preserved? Yes / No
    a. If metals preserved upon receipt: Date: Time: By/Acid Lot#:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

COC = DU-2-22 collected 1055 ; Labels = DU-2-26 collected 1055

14. Was there a need to contact Project Manager? Yes / No (MM 5/11/22)
    a. Was there a need to contact the client? Yes / No
    Who was contacted? ~~Julianne Marrion~~ Date: 5/12/22 Time: 1700 By: ML

Resolution:

Bottle are correct

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	290557	Yes	N/A	Yes	1L Poly	H2SO4	
1	290566	Yes	N/A	Yes	250 mL Poly	NP	
1	290575	Yes	N/A	Yes	250 mL Amber	NP	
1	290584	Yes	N/A	Yes	250 mL Poly	NP	
2	290558	Yes	N/A	Yes	1L Poly	H2SO4	
2	290567	Yes	N/A	Yes	250 mL Poly	NP	
2	290576	Yes	N/A	Yes	250 mL Amber	NP	
2	290585	Yes	N/A	Yes	250 mL Poly	NP	
3	290559	Yes	N/A	Yes	1L Poly	H2SO4	
3	290568	Yes	N/A	Yes	250 mL Poly	NP	
3	290577	Yes	N/A	Yes	250 mL Amber	NP	
3	290586	Yes	N/A	Yes	250 mL Poly	NP	
4	290560	Yes	N/A	Yes	1L Poly	H2SO4	
4	290569	Yes	N/A	Yes	250 mL Poly	NP	
4	290578	Yes	N/A	Yes	250 mL Amber	NP	
4	290587	Yes	N/A	Yes	250 mL Poly	NP	
5	290561	Yes	N/A	Yes	1L Poly	H2SO4	

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

ESS Project ID: 22E0397
Date Received: 5/11/2022

5	290570	Yes	N/A	Yes	250 mL Poly	NP
5	290579	Yes	N/A	Yes	250 mL Amber	NP
5	290588	Yes	N/A	Yes	250 mL Poly	NP
6	290562	Yes	N/A	Yes	1L Poly	H2SO4
6	290571	Yes	N/A	Yes	250 mL Poly	NP
6	290580	Yes	N/A	Yes	250 mL Amber	NP
6	290589	Yes	N/A	Yes	250 mL Poly	NP
7	290563	Yes	N/A	Yes	1L Poly	H2SO4
7	290572	Yes	N/A	Yes	250 mL Poly	NP
7	290581	Yes	N/A	Yes	250 mL Amber	NP
7	290590	Yes	N/A	Yes	250 mL Poly	NP
8	290564	Yes	N/A	Yes	1L Poly	H2SO4
8	290573	Yes	N/A	Yes	250 mL Poly	NP
8	290582	Yes	N/A	Yes	250 mL Amber	NP
8	290591	Yes	N/A	Yes	250 mL Poly	NP
9	290565	Yes	N/A	Yes	1L Poly	H2SO4
9	290574	Yes	N/A	Yes	250 mL Poly	NP
9	290583	Yes	N/A	Yes	250 mL Amber	NP
9	290592	Yes	N/A	Yes	250 mL Poly	NP

2nd Review

Were all containers scanned into storage/lab? Initials KL

Are barcode labels on correct containers? Yes / No

Are all Flashpoint stickers attached/container ID # circled? Yes / No / NA

Are all Hex Chrome stickers attached? Yes / No / NA

Are all QC stickers attached? Yes / No / NA

Are VOA stickers attached if bubbles noted? Yes / No / NA

Completed By: [signature] Date & Time: 5.11.22 1721

Reviewed By: [signature] Date & Time: 5/11/22 1727

ESS Laboratory
Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 22E0397

Turn Time	5	Days
Regulatory State	Massachusetts	

Is this project for any of the following?: ○ CT RCP ○ MA MCP ○ RGP

Reporting Limits

Electonic Deliverables ☐ Data Checker ☐ Excel ☐ Other (Please Specify →)

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB

Address			
250 Apollo Dr			
City	**State**	**Zip Code**	**PO #**
Chelmsford	MA	01824	
Telephone Number	**FAX Number**	**Email Address**	
978-905-2419		julianne.marrion@aecom.com	

Julianne Marrion

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: Total Nitrogen	Nitrate, Nitrite	Lab Filter Dissolved Fe, Mn	DOC
1	5.10.22	0955	Grab	Ground Water	DU-2 ~~22~~ 26	X	X	X	X
2		1020	Grab	Ground Water	DU-2-63 ML - 5/18/22				
3		1005	Grab	Ground Water	DU-2-100				
4		1285	Grab	Ground Water	DU-1-37				
5		1150	Grab	Ground Water	DU-1-68				
6		1205	Grab	Ground Water	DU-1-100				
7		1500	Grab	Ground Water	DU-3-51				
8		1337	Grab	Ground Water	DU-3-76				
9		1415	Grab	Ground Water	DU-3-100				
			Grab	Ground Water					

Container Type: AC-Air Cassette AG-Amber Glass B-BOD Bottle C-Cubitainer J-Jar O-Other P-Poly S-Sterile V-Vial

Container Volume: 1-100 mL 2-2.5 gal 3-250 mL 4-300 mL 5-500 mL 6-1L 7-VOA 8-2 oz 9-4 oz 10-8 oz 11-Other*

Preservation Code: 1-Non Preserved 2-HCl 3-H2SO4 4-HNO3 5-NaOH 6-Methanol 7-Na2S2O3 8-ZnAce, NaOH 9-NH4Cl 10-DI H2O 11-Other*

	Total Nitrogen	Nitrate, Nitrite	Lab Filter Dissolved Fe, Mn	DOC	
Container Type:	P	P	P	AG	V
Container Volume:	6	3	3	3	7
Preservation Code:	3	1	1	1	2
Number of Containers per Sample:	1	1	1	1	2

Laboratory Use Only

Cooler Present: yes ○ Drop Off
Seals Intact: ○ Pickup
Cooler Temperature: 1.9 °C Ice

Sampled by : CHayden

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
CHayden 5/10/22	5/10/22	5/11/22	5/11/22 10:56
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
5/11/22 16:51	5.11.22 1651		

CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 22E0414

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 5:08 pm, May 23, 2022

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0414

SAMPLE RECEIPT

The following samples were received on May 11, 2022 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
22E0414-01	DU-4-52	Ground Water	200.7, 353.2, 4500N, 5310B
22E0414-02	DU-4-76	Ground Water	200.7, 353.2, 4500N, 5310B
22E0414-03	DU-4-100	Ground Water	200.7, 353.2, 4500N, 5310B

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0414

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0414

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-4-52
Date Sampled: 05/11/22 12:10
Percent Solids: N/A

ESS Laboratory Work Order: 22E0414
ESS Laboratory Sample ID: 22E0414-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 20:38	10	10	DE21338
Manganese	**0.020** (0.020)		200.7		1	KJK	05/17/22 20:38	10	10	DE21338

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-4-52
Date Sampled: 05/11/22 12:10
Percent Solids: N/A

ESS Laboratory Work Order: 22E0414
ESS Laboratory Sample ID: 22E0414-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.896** (0.500)		5310B		1	CCP	05/12/22 18:27	mg/L	[CALC]
Nitrate as N	**1.32** (0.110)		353.2		5	JLK	05/11/22 19:04	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/11/22 17:53	mg/L	DE21127
Total Nitrogen	**1.32** (0.200)		4500N		5	JLK	05/23/22 14:15	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-4-76
Date Sampled: 05/11/22 10:55
Percent Solids: N/A

ESS Laboratory Work Order: 22E0414
ESS Laboratory Sample ID: 22E0414-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 20:40	10	10	DE21338
Manganese	**0.113** (0.020)		200.7		1	KJK	05/17/22 20:40	10	10	DE21338

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-4-76
Date Sampled: 05/11/22 10:55
Percent Solids: N/A

ESS Laboratory Work Order: 22E0414
ESS Laboratory Sample ID: 22E0414-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.926** (0.500)		5310B		1	CCP	05/12/22 19:28	mg/L	[CALC]
Nitrate as N	**1.73** (0.110)		353.2		5	JLK	05/11/22 19:05	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/11/22 17:54	mg/L	DE21127
Total Nitrogen	**1.73** (0.200)		4500N		5	JLK	05/23/22 14:18	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-4-100
Date Sampled: 05/11/22 11:30
Percent Solids: N/A

ESS Laboratory Work Order: 22E0414
ESS Laboratory Sample ID: 22E0414-03
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 20:48	10	10	DE21338
Manganese	**0.166** (0.020)		200.7		1	KJK	05/17/22 20:48	10	10	DE21338

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-4-100
Date Sampled: 05/11/22 11:30
Percent Solids: N/A

ESS Laboratory Work Order: 22E0414
ESS Laboratory Sample ID: 22E0414-03
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.896** (0.500)		5310B		1	CCP	05/12/22 19:40	mg/L	[CALC]
Nitrate as N	**1.58** (0.110)		353.2		5	JLK	05/11/22 19:06	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/11/22 17:55	mg/L	DE21127
Total Nitrogen	**1.58** (0.200)		4500N		5	JLK	05/23/22 14:19	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0414

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DE21338 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.52		mg/L	2.500		101	80-120			
Manganese	0.516		mg/L	0.5000		103	80-120			
Classical Chemistry										
Batch DE21127 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.249		mg/L	0.2497		100	90-110			
Nitrite as N	0.249		mg/L	0.2497		100	90-110			
Batch DE21129 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.522		mg/L	0.5000		104	90-110			
Nitrate/Nitrite as N	0.522		mg/L	0.5000		104	90-110			
Batch DE21242 - General Preparation										
Blank										
Dissolved Organic Carbon (1)	ND	0.500	mg/L							
Dissolved Organic Carbon (2)	ND	0.500	mg/L							
LCS										
Dissolved Organic Carbon (1)	5.62	0.500	mg/L	5.000		112	80-120			
Dissolved Organic Carbon (2)	5.72	0.500	mg/L	5.000		114	80-120			
LCS Dup										
Dissolved Organic Carbon (1)	5.68	0.500	mg/L	5.000		114	80-120	1	20	
Dissolved Organic Carbon (2)	5.65	0.500	mg/L	5.000		113	80-120	1	20	
Batch DE21913 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	14.5	2.00	mg/L	13.20		110	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0414

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0414

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ESS Courier

ESS Project ID: 22E0414
Date Received: 5/11/2022
Project Due Date: 5/18/2022
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 4.1 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** Yes / No / NA
10. Were any analyses received outside of hold time? Yes / No

11. Any Subcontracting needed? Yes / No
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / No
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA

13. Are the samples properly preserved? Yes / No
    a. If metals preserved upon receipt: Date: Time: By/Acid Lot#:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

14. Was there a need to contact Project Manager? Yes / No
    a. Was there a need to contact the client? Yes / No
    Who was contacted? Date: Time: By:

Resolution:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	290700	Yes	N/A	Yes	1L Poly	H2SO4	
1	290703	Yes	N/A	Yes	250 mL Poly	NP	
1	290706	Yes	N/A	Yes	250 mL Poly	NP	
1	290709	Yes	N/A	Yes	250 mL Amber	NP	
2	290701	Yes	N/A	Yes	1L Poly	H2SO4	
2	290704	Yes	N/A	Yes	250 mL Poly	NP	
2	290707	Yes	N/A	Yes	250 mL Poly	NP	
2	290710	Yes	N/A	Yes	250 mL Amber	NP	
3	290702	Yes	N/A	Yes	1L Poly	H2SO4	
3	290705	Yes	N/A	Yes	250 mL Poly	NP	
3	290708	Yes	N/A	Yes	250 mL Poly	NP	
3	290711	Yes	N/A	Yes	250 mL Amber	NP	

2nd Review
Were all containers scanned into storage/lab? Initials
Are barcode labels on correct containers? Yes / No
Are all Flashpoint stickers attached/container ID # circled? Yes / No / NA

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

ESS Project ID: 22E0414
Date Received: 5/11/2022

Are all Hex Chrome stickers attached?	Yes / No / NA
Are all QC stickers attached?	Yes / No / NA
Are VOA stickers attached if bubbles noted?	Yes / No / NA

Completed By: Taylor Davis Date & Time: 1720 5/11/22.

Reviewed By: Date & Time: 5/11/22 1734

ESS Laboratory
Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 22604114.

Turn Time: 5 Days
Regulatory State: Massachusetts
Is this project for any of the following?: ○ CT RCP ○ MA MCP ○ RGP
Reporting Limits
Electonic Deliverables: ☐ Data Checker ☐ Excel ☐ Other (Please Specify →)

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB

	Address
Julianne Marrion	250 Apollo Dr

City	State	Zip Code	PO #
Chelmsford	MA	01824	

Telephone Number	FAX Number	Email Address
978-905-2419		julianne.marrion@aecom.com

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: Total Nitrogen	Nitrate, Nitrite	Lab Filter Dissolved Fe, Mn	DOC
1	5.11.22	1210	Grab	Ground Water	DU-4-52	X	X	X	X
2		1055	Grab	Ground Water	DU-4-76	X	X	X	X
3		1130	Grab	Ground Water	DU-4-100	X	X	X	X
			Grab	Ground Water					
			Grab	Ground Water					
			Grab	Ground Water					
			Grab	Ground Water					
			Grab	Ground Water					
			Grab	Ground Water					
			Grab	Ground Water					

Container Type:	AC-Air Cassette	AG-Amber Glass	B-BOD Bottle	C-Cubitainer	J-Jar	O-Other	P-Poly	S-Sterile	V-Vial	P	P	P	AG	V
Container Volume:	1-100 mL	2-2.5 gal	3-250 mL	4-300 mL	5-500 mL	6-1L	7-VOA	8-2 oz	9-4 oz	10-8 oz	11-Other*	6	3	3	3	7
Preservation Code:	1-Non Preserved	2-HCl	3-H2SO4	4-HNO3	5-NaOH	6-Methanol	7-Na2S2O3	8-ZnAce, NaOH	9-NH4Cl	10-DI H2O	11-Other*	3	1	1	1	2
											Number of Containers per Sample:	1	1	1	1	2

Laboratory Use Only
Cooler Present: YES ○ Drop Off
Seals Intact: ○ Pickup
Cooler Temperature: 4.1 °C IR

Sampled by : C.Hayden
Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
C.Hayden 5.11.22 1530	5/11/22 15:30	5/11/22 17:04	Taylor Dare 1704 5/11/22
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 22E0484

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 12:17 pm, May 27, 2022

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0484

SAMPLE RECEIPT

The following samples were received on May 12, 2022 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
22E0484-01	BR-1-55	Ground Water	200.7, 353.2, 4500N, 5310B
22E0484-02	BR-1-77	Ground Water	200.7, 353.2, 4500N, 5310B
22E0484-03	BR-1-98	Ground Water	200.7, 353.2, 4500N, 5310B
22E0484-04	BR-2-36	Ground Water	200.7, 353.2, 4500N, 5310B
22E0484-05	BR-2-66	Ground Water	200.7, 353.2, 4500N, 5310B
22E0484-06	BR-2-96	Ground Water	200.7, 353.2, 4500N, 5310B
22E0484-07	BR-3-60	Ground Water	200.7, 353.2, 4500N, 5310B
22E0484-08	BR-3-80	Ground Water	200.7, 353.2, 4500N, 5310B
22E0484-09	BR-3-100	Ground Water	200.7, 353.2, 4500N, 5310B
22E0484-10	BR-6-100	Ground Water	200.7, 353.2, 4500N, 5310B

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0484

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

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Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0484

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-1-55
Date Sampled: 05/12/22 13:15
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 22:04	10	10	DE21339
Manganese	**0.034** (0.020)		200.7		1	KJK	05/17/22 22:04	10	10	DE21339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-1-55
Date Sampled: 05/12/22 13:15
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.855** (0.500)		5310B		1	CCP	05/13/22 20:47	mg/L	[CALC]
Nitrate as N	**0.758** (0.0300)		353.2		1	EAM	05/13/22 18:02	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/13/22 17:01	mg/L	DE21344
Total Nitrogen	**0.758** (0.200)		4500N		1	JLK	05/23/22 14:31	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-1-77
Date Sampled: 05/12/22 13:45
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 22:07	10	10	DE21339
Manganese	**0.037** (0.020)		200.7		1	KJK	05/17/22 22:07	10	10	DE21339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-1-77
Date Sampled: 05/12/22 13:45
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.24** (0.500)		5310B		1	CCP	05/13/22 21:49	mg/L	[CALC]
Nitrate as N	**1.99** (0.0500)		353.2		2	EAM	05/13/22 18:30	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/13/22 17:03	mg/L	DE21344
Total Nitrogen	**1.99** (0.200)		4500N		2	JLK	05/23/22 14:32	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-1-98
Date Sampled: 05/12/22 13:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-03
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 22:09	10	10	DE21339
Manganese	**0.055** (0.020)		200.7		1	KJK	05/17/22 22:09	10	10	DE21339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-1-98
Date Sampled: 05/12/22 13:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-03
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.32** (0.500)		5310B		1	CCP	05/13/22 22:01	mg/L	[CALC]
Nitrate as N	**0.293** (0.0300)		353.2		1	EAM	05/13/22 18:16	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/13/22 17:15	mg/L	DE21344
Total Nitrogen	**0.293** (0.200)		4500N		1	JLK	05/23/22 14:33	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-2-36
Date Sampled: 05/12/22 12:00
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-04
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 22:11	10	10	DE21339
Manganese	ND (0.020)		200.7		1	KJK	05/17/22 22:11	10	10	DE21339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-2-36
Date Sampled: 05/12/22 12:00
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-04
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.24** (0.500)		5310B		1	CCP	05/13/22 22:13	mg/L	[CALC]
Nitrate as N	**1.35** (0.0500)		353.2		2	EAM	05/13/22 18:35	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/13/22 17:16	mg/L	DE21344
Total Nitrogen	**1.35** (0.200)		4500N		2	JLK	05/23/22 14:34	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-2-66
Date Sampled: 05/12/22 11:00
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-05
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 22:13	10	10	DE21339
Manganese	ND (0.020)		200.7		1	KJK	05/17/22 22:13	10	10	DE21339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-2-66
Date Sampled: 05/12/22 11:00
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-05
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.897** (0.500)		5310B		1	CCP	05/13/22 22:50	mg/L	[CALC]
Nitrate as N	**0.827** (0.0300)		353.2		1	EAM	05/13/22 18:18	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/13/22 17:16	mg/L	DE21344
Total Nitrogen	**0.827** (0.200)		4500N		1	JLK	05/23/22 14:34	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-2-96
Date Sampled: 05/12/22 11:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-06
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**3.92** (0.100)		200.7		1	KJK	05/17/22 22:15	10	10	DE21339
Manganese	**0.225** (0.020)		200.7		1	KJK	05/17/22 22:15	10	10	DE21339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-2-96
Date Sampled: 05/12/22 11:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-06
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.49** (0.500)		5310B		1	CCP	05/13/22 23:02	mg/L	[CALC]
Nitrate as N	ND (0.0300)		353.2		1	EAM	05/13/22 18:19	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/13/22 17:17	mg/L	DE21344
Total Nitrogen	**1.50** (0.200)		4500N		1	JLK	05/23/22 14:35	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-3-60
Date Sampled: 05/12/22 09:35
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-07
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.241** (0.100)		200.7		1	KJK	05/17/22 22:18	10	10	DE21339
Manganese	ND (0.020)		200.7		1	KJK	05/17/22 22:18	10	10	DE21339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-3-60
Date Sampled: 05/12/22 09:35
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-07
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**6.19** (0.500)		5310B		1	CCP	05/13/22 23:15	mg/L	[CALC]
Nitrate as N	**0.631** (0.0300)		353.2		1	EAM	05/13/22 18:20	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/13/22 17:18	mg/L	DE21344
Total Nitrogen	**0.947** (0.200)		4500N		1	JLK	05/23/22 14:42	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-3-80
Date Sampled: 05/12/22 09:45
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-08
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 22:28	10	10	DE21339
Manganese	**0.022** (0.020)		200.7		1	KJK	05/17/22 22:28	10	10	DE21339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-3-80
Date Sampled: 05/12/22 09:45
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-08
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.12** (0.500)		5310B		1	CCP	05/13/22 23:27	mg/L	[CALC]
Nitrate as N	**0.654** (0.0300)		353.2		1	EAM	05/13/22 18:21	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/13/22 17:19	mg/L	DE21344
Total Nitrogen	**0.963** (0.200)		4500N		1	JLK	05/23/22 14:42	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-3-100
Date Sampled: 05/12/22 08:50
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-09
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**6.03** (0.100)		200.7		1	KJK	05/17/22 22:31	10	10	DE21339
Manganese	**1.51** (0.020)		200.7		1	KJK	05/17/22 22:31	10	10	DE21339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-3-100
Date Sampled: 05/12/22 08:50
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-09
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.20** (0.500)		5310B		1	CCP	05/13/22 23:39	mg/L	[CALC]
Nitrate as N	ND (0.0300)		353.2		1	EAM	05/13/22 18:22	mg/L	[CALC]
Nitrite as N	**0.012** (0.010)		353.2		1	EAM	05/13/22 17:20	mg/L	DE21344
Total Nitrogen	**0.815** (0.200)		4500N		1	JLK	05/23/22 14:43	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-6-100
Date Sampled: 05/12/22 14:55
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-10
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**3.89** (0.100)		200.7		1	KJK	05/17/22 22:33	10	10	DE21339
Manganese	**0.194** (0.020)		200.7		1	KJK	05/17/22 22:33	10	10	DE21339

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-6-100
Date Sampled: 05/12/22 14:55
Percent Solids: N/A

ESS Laboratory Work Order: 22E0484
ESS Laboratory Sample ID: 22E0484-10
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.38** (0.500)		5310B		1	CCP	05/14/22 0:16	mg/L	[CALC]
Nitrate as N	ND (0.0300)		353.2		1	EAM	05/13/22 18:27	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/13/22 17:26	mg/L	DE21344
Total Nitrogen	**0.405** (0.200)		4500N		1	JLK	05/23/22 15:19	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0484

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DE21339 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.52		mg/L	2.500		101	80-120			
Manganese	0.516		mg/L	0.5000		103	80-120			
Classical Chemistry										
Batch DE21344 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.247	0.010	mg/L	0.2497		99	90-110			
Nitrite as N	0.247	0.010	mg/L	0.2497		99	90-110			
Batch DE21345 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.488		mg/L	0.5000		98	90-110			
Batch DE21357 - General Preparation										
Blank										
Dissolved Organic Carbon (1)	ND	0.500	mg/L							
Dissolved Organic Carbon (2)	ND	0.500	mg/L							
LCS										
Dissolved Organic Carbon (1)	4.77	0.500	mg/L	5.000		95	80-120			
Dissolved Organic Carbon (2)	4.90	0.500	mg/L	5.000		98	80-120			
LCS Dup										
Dissolved Organic Carbon (1)	5.12	0.500	mg/L	5.000		102	80-120	7	20	
Dissolved Organic Carbon (2)	5.10	0.500	mg/L	5.000		102	80-120	4	20	
Batch DE21913 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	14.5	2.00	mg/L	13.20		110	80-120			
Batch DE22034 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	12.8	2.00	mg/L	13.20		97	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0484

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0484

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ESS Courier

ESS Project ID: 22E0484
Date Received: 5/12/2022
Project Due Date: 5/19/2022
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 3.8 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** (Yes) / No / NA
10. Were any analyses received outside of hold time? Yes / (No)

11. Any Subcontracting needed? (Yes) / No
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / (No)
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA
13. Are the samples properly preserved? (Yes) / No
    a. If metals preserved upon receipt: Date: Time: By/Acid Lot#:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

14. Was there a need to contact Project Manager? Yes / (No)
    a. Was there a need to contact the client? Yes / No
    Who was contacted? Date: Time: By:

Resolution:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	291393	Yes	N/A	Yes	250 mL Amber	NP	
1	291403	Yes	N/A	Yes	250 mL Poly	NP	
1	291404	Yes	N/A	Yes	250 mL Poly	NP	
1	291423	Yes	N/A	Yes	1L Poly	H2SO4	
2	291394	Yes	N/A	Yes	250 mL Amber	NP	
2	291405	Yes	N/A	Yes	250 mL Poly	NP	
2	291406	Yes	N/A	Yes	250 mL Poly	NP	
2	291424	Yes	N/A	Yes	1L Poly	H2SO4	
3	291395	Yes	N/A	Yes	250 mL Amber	NP	
3	291407	Yes	N/A	Yes	250 mL Poly	NP	
3	291408	Yes	N/A	Yes	250 mL Poly	NP	
3	291425	Yes	N/A	Yes	1L Poly	H2SO4	
4	291396	Yes	N/A	Yes	250 mL Amber	NP	
4	291409	Yes	N/A	Yes	250 mL Poly	NP	
4	291410	Yes	N/A	Yes	250 mL Poly	NP	
4	291426	Yes	N/A	Yes	1L Poly	H2SO4	
5	291397	Yes	N/A	Yes	250 mL Amber	NP	

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

ESS Project ID: 22E0484
Date Received: 5/12/2022

5	291411	Yes	N/A	Yes	250 mL Poly	NP
5	291412	Yes	N/A	Yes	250 mL Poly	NP
5	291427	Yes	N/A	Yes	1L Poly	H2SO4
6	291398	Yes	N/A	Yes	250 mL Amber	NP
6	291413	Yes	N/A	Yes	250 mL Poly	NP
6	291414	Yes	N/A	Yes	250 mL Poly	NP
6	291428	Yes	N/A	Yes	1L Poly	H2SO4
7	291399	Yes	N/A	Yes	250 mL Amber	NP
7	291415	Yes	N/A	Yes	250 mL Poly	NP
7	291416	Yes	N/A	Yes	250 mL Poly	NP
7	291429	Yes	N/A	Yes	1L Poly	H2SO4
8	291400	Yes	N/A	Yes	250 mL Amber	NP
8	291417	Yes	N/A	Yes	250 mL Poly	NP
8	291418	Yes	N/A	Yes	250 mL Poly	NP
8	291430	Yes	N/A	Yes	1L Poly	H2SO4
9	291401	Yes	N/A	Yes	250 mL Amber	NP
9	291419	Yes	N/A	Yes	250 mL Poly	NP
9	291420	Yes	N/A	Yes	250 mL Poly	NP
9	291431	Yes	N/A	Yes	1L Poly	H2SO4
10	291402	Yes	N/A	Yes	250 mL Amber	NP
10	291421	Yes	N/A	Yes	250 mL Poly	NP
10	291422	Yes	N/A	Yes	250 mL Poly	NP
10	291432	Yes	N/A	Yes	1L Poly	H2SO4

2nd Review

Were all containers scanned into storage/lab? Initials TD

Are barcode labels on correct containers? (Yes) / No

Are all Flashpoint stickers attached/container ID # circled? Yes / No / (NA)

Are all Hex Chrome stickers attached? Yes / No / (NA)

Are all QC stickers attached? Yes / No / (NA)

Are VOA stickers attached if bubbles noted? Yes / No / (NA)

Completed By: Yaritza Davila Date & Time: 5/12/22 1853.

Reviewed By: JH Date & Time: 5/18/22 1647

ESS Laboratory

Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 22E0484

Turn Time: 5 Days
Regulatory State: Massachusetts
Is this project for any of the following?: ○ CT RCP ○ MA MCP ○ RGP
Reporting Limits
Electonic Deliverables: ☐ Data Checker ☐ Excel ☐ Other (Please Specify →)

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB

Address	City	State	Zip Code	PO #
250 Apollo Dr	Chelmsford	MA	01824	

Telephone Number	FAX Number	Email Address
978-905-2419		julianne.marrion@aecom.com

Julianne Marrion

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: Total Nitrogen	Nitrate, Nitrite	Lab Filter Dissolved Fe, Mn	DOC													
1	5.12.22	1315	Grab	Ground Water	BR-1-55	X	X	X	X													
2		1345	Grab	Ground Water	BR-1-77																	
3		1355	Grab	Ground Water	BR-1-98																	
4		1200	Grab	Ground Water	BR-2-36																	
5		1100	Grab	Ground Water	BR-2-66																	
6		1105	Grab	Ground Water	BR-2-96																	
7		0735	Grab	Ground Water	BR-3-60																	
8		0845	Grab	Ground Water	BR-3-80																	
9		0850	Grab	Ground Water	BR-3-100																	
10		1455	Grab	Ground Water	BR-6-100																	

Container Type:	AC-Air Cassette	AG-Amber Glass	B-BOD Bottle	C-Cubitainer	J-Jar	O-Other	P-Poly	S-Sterile	V-Vial	P	P	P	AG	V								
Container Volume:	1-100 mL	2-2.5 gal	3-250 mL	4-300 mL	5-500 mL	6-1L	7-VOA	8-2 oz	9-4 oz	10-8 oz	11-Other*	6	3	3	3	7						
Preservation Code:	1-Non Preserved	2-HCl	3-H2SO4	4-HNO3	5-NaOH	6-Methanol	7-Na2S2O3	8-ZnAce, NaOH	9-NH4Cl	10-DI H2O	11-Other*	3	1	1	1	2						
											Number of Containers per Sample:	1	1	1	1	2						

Laboratory Use Only
Cooler Present: Yes ○ Drop Off
Seals Intact: ○ Pickup
Cooler Temperature: 3.8 °C / Ice

Sampled by :
Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
C. Hayden 5.12.22 1645	5/12/22 16:50	5/12/22 18:32	Yaniv Davis 1832 5/12/22
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 22E0534

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 12:24 pm, May 24, 2022

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0534

SAMPLE RECEIPT

The following samples were received on May 13, 2022 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
22E0534-01	DU-5-34	Ground Water	200.7, 353.2, 4500N, 5310B
22E0534-02	DU-5-67	Ground Water	200.7, 353.2, 4500N, 5310B
22E0534-03	DU-5-100	Ground Water	200.7, 353.2, 4500N, 5310B
22E0534-04	DU-6-33	Ground Water	200.7, 353.2, 4500N, 5310B
22E0534-05	DU-6-67	Ground Water	200.7, 353.2, 4500N, 5310B
22E0534-06	DU-6-100	Ground Water	200.7, 353.2, 4500N, 5310B
22E0534-07	RI-1-105	Ground Water	200.7, 353.2, 4500N, 5310B

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0534

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0534

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-5-34
Date Sampled: 05/13/22 10:40
Percent Solids: N/A

ESS Laboratory Work Order: 22E0534
ESS Laboratory Sample ID: 22E0534-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 23:01	10	10	DE21728
Manganese	**0.028** (0.020)		200.7		1	KJK	05/17/22 23:01	10	10	DE21728

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-5-34
Date Sampled: 05/13/22 10:40
Percent Solids: N/A

ESS Laboratory Work Order: 22E0534
ESS Laboratory Sample ID: 22E0534-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.41** (0.500)		5310B		1	CCP	05/14/22 0:40	mg/L	[CALC]
Nitrate as N	**0.830** (0.0300)		353.2		1	EAM	05/13/22 20:59	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/13/22 20:13	mg/L	DE21346
Total Nitrogen	**1.16** (0.200)		4500N		1	JLK	05/23/22 15:21	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-5-67
Date Sampled: 05/13/22 10:10
Percent Solids: N/A

ESS Laboratory Work Order: 22E0534
ESS Laboratory Sample ID: 22E0534-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 23:09	10	10	DE21728
Manganese	ND (0.020)		200.7		1	KJK	05/17/22 23:09	10	10	DE21728

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-5-67
Date Sampled: 05/13/22 10:10
Percent Solids: N/A

ESS Laboratory Work Order: 22E0534
ESS Laboratory Sample ID: 22E0534-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.04** (0.500)		5310B		1	CCP	05/14/22 0:53	mg/L	[CALC]
Nitrate as N	**1.04** (0.0500)		353.2		2	EAM	05/13/22 21:16	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/13/22 20:14	mg/L	DE21346
Total Nitrogen	**1.82** (0.200)		4500N		2	JLK	05/23/22 15:22	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-5-100
Date Sampled: 05/13/22 10:00
Percent Solids: N/A

ESS Laboratory Work Order: 22E0534
ESS Laboratory Sample ID: 22E0534-03
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 23:12	10	10	DE21728
Manganese	**0.041** (0.020)		200.7		1	KJK	05/17/22 23:12	10	10	DE21728

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-5-100
Date Sampled: 05/13/22 10:00
Percent Solids: N/A

ESS Laboratory Work Order: 22E0534
ESS Laboratory Sample ID: 22E0534-03
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.776** (0.500)		5310B		1	CCP	05/14/22 1:05	mg/L	[CALC]
Nitrate as N	**0.232** (0.0300)		353.2		1	EAM	05/13/22 21:01	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/13/22 20:15	mg/L	DE21346
Total Nitrogen	**0.581** (0.200)		4500N		1	JLK	05/23/22 15:22	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-6-33
Date Sampled: 05/13/22 12:50
Percent Solids: N/A

ESS Laboratory Work Order: 22E0534
ESS Laboratory Sample ID: 22E0534-04
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 23:14	10	10	DE21728
Manganese	**0.110** (0.020)		200.7		1	KJK	05/17/22 23:14	10	10	DE21728

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-6-33
Date Sampled: 05/13/22 12:50
Percent Solids: N/A

ESS Laboratory Work Order: 22E0534
ESS Laboratory Sample ID: 22E0534-04
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.18** (0.500)		5310B		1	CCP	05/14/22 1:42	mg/L	[CALC]
Nitrate as N	**1.61** (0.110)		353.2		5	EAM	05/13/22 21:17	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/13/22 20:15	mg/L	DE21346
Total Nitrogen	**1.61** (0.200)		4500N		5	JLK	05/23/22 15:29	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-6-67
Date Sampled: 05/13/22 12:00
Percent Solids: N/A

ESS Laboratory Work Order: 22E0534
ESS Laboratory Sample ID: 22E0534-05
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 23:16	10	10	DE21728
Manganese	ND (0.020)		200.7		1	KJK	05/17/22 23:16	10	10	DE21728

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-6-67
Date Sampled: 05/13/22 12:00
Percent Solids: N/A

ESS Laboratory Work Order: 22E0534
ESS Laboratory Sample ID: 22E0534-05
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.17** (0.500)		5310B		1	CCP	05/14/22 1:54	mg/L	[CALC]
Nitrate as N	**3.66** (0.110)		353.2		5	EAM	05/13/22 21:18	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/13/22 20:16	mg/L	DE21346
Total Nitrogen	**3.66** (0.200)		4500N		5	JLK	05/23/22 15:30	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-6-100
Date Sampled: 05/13/22 11:55
Percent Solids: N/A

ESS Laboratory Work Order: 22E0534
ESS Laboratory Sample ID: 22E0534-06
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 23:18	10	10	DE21728
Manganese	**0.050** (0.020)		200.7		1	KJK	05/17/22 23:18	10	10	DE21728

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: DU-6-100
Date Sampled: 05/13/22 11:55
Percent Solids: N/A

ESS Laboratory Work Order: 22E0534
ESS Laboratory Sample ID: 22E0534-06
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.14** (0.500)		5310B		1	CCP	05/14/22 2:06	mg/L	[CALC]
Nitrate as N	**1.45** (0.110)		353.2		5	EAM	05/13/22 21:19	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/13/22 20:22	mg/L	DE21346
Total Nitrogen	**1.45** (0.200)		4500N		5	JLK	05/23/22 15:30	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: RI-1-105
Date Sampled: 05/13/22 13:55
Percent Solids: N/A

ESS Laboratory Work Order: 22E0534
ESS Laboratory Sample ID: 22E0534-07
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/17/22 23:27	10	10	DE21728
Manganese	ND (0.020)		200.7		1	KJK	05/17/22 23:27	10	10	DE21728

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: RI-1-105
Date Sampled: 05/13/22 13:55
Percent Solids: N/A

ESS Laboratory Work Order: 22E0534
ESS Laboratory Sample ID: 22E0534-07
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.965** (0.500)		5310B		1	CCP	05/14/22 2:18	mg/L	[CALC]
Nitrate as N	**0.431** (0.0300)		353.2		1	EAM	05/13/22 21:14	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/13/22 20:23	mg/L	DE21346
Total Nitrogen	**0.431** (0.200)		4500N		1	JLK	05/23/22 15:31	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0534

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DE21728 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.52		mg/L	2.500		101	80-120			
Manganese	0.516		mg/L	0.5000		103	80-120			
Classical Chemistry										
Batch DE21346 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.244	0.010	mg/L	0.2497		98	90-110			
Nitrite as N	0.244	0.010	mg/L	0.2497		98	90-110			
Batch DE21347 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.489		mg/L	0.5000		98	90-110			
Nitrate/Nitrite as N	0.489		mg/L	0.5000		98	90-110			
Batch DE21357 - General Preparation										
Blank										
Dissolved Organic Carbon (1)	ND	0.500	mg/L							
Dissolved Organic Carbon (2)	ND	0.500	mg/L							
LCS										
Dissolved Organic Carbon (1)	4.77	0.500	mg/L	5.000		95	80-120			
Dissolved Organic Carbon (2)	4.90	0.500	mg/L	5.000		98	80-120			
LCS Dup										
Dissolved Organic Carbon (1)	5.12	0.500	mg/L	5.000		102	80-120	7	20	
Dissolved Organic Carbon (2)	5.10	0.500	mg/L	5.000		102	80-120	4	20	
Batch DE22034 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	12.8	2.00	mg/L	13.20		97	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0534

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0534

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ESS Courier

ESS Project ID: 22E0534
Date Received: 5/13/2022
Project Due Date: 5/20/2022
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 2.1 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** (Yes) / No / NA
10. Were any analyses received outside of hold time? Yes / (No)

11. Any Subcontracting needed? Yes / (No)
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / (No)
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA

13. Are the samples properly preserved? (Yes) / No
    a. If metals preserved upon receipt: Date: Time: By/Acid Lot#:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

14. Was there a need to contact Project Manager? Yes / (No)
    a. Was there a need to contact the client? Yes / No
    Who was contacted? Date: Time: By:

Resolution:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	291780	Yes	N/A	Yes	1L Poly	H2SO4	
1	291787	Yes	N/A	Yes	250 mL Amber	NP	
1	291794	Yes	N/A	Yes	250 mL Poly	NP	
1	291795	Yes	N/A	Yes	250 mL Poly	NP	
2	291781	Yes	N/A	Yes	1L Poly	H2SO4	
2	291788	Yes	N/A	Yes	250 mL Amber	NP	
2	291796	Yes	N/A	Yes	250 mL Poly	NP	
2	291797	Yes	N/A	Yes	250 mL Poly	NP	
3	291782	Yes	N/A	Yes	1L Poly	H2SO4	
3	291789	Yes	N/A	Yes	250 mL Amber	NP	
3	291798	Yes	N/A	Yes	250 mL Poly	NP	
3	291799	Yes	N/A	Yes	250 mL Poly	NP	
4	291783	Yes	N/A	Yes	1L Poly	H2SO4	
4	291790	Yes	N/A	Yes	250 mL Amber	NP	
4	291800	Yes	N/A	Yes	250 mL Poly	NP	
4	291801	Yes	N/A	Yes	250 mL Poly	NP	
5	291784	Yes	N/A	Yes	1L Poly	H2SO4	

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

ESS Project ID: 22E0534
Date Received: 5/13/2022

5	291791	Yes	N/A	Yes	250 mL Amber	NP
5	291802	Yes	N/A	Yes	250 mL Poly	NP
5	291803	Yes	N/A	Yes	250 mL Poly	NP
6	291785	Yes	N/A	Yes	1L Poly	H2SO4
6	291792	Yes	N/A	Yes	250 mL Amber	NP
6	291804	Yes	N/A	Yes	250 mL Poly	NP
6	291805	Yes	N/A	Yes	250 mL Poly	NP
7	291786	Yes	N/A	Yes	1L Poly	H2SO4
7	291793	Yes	N/A	Yes	250 mL Amber	NP
7	291806	Yes	N/A	Yes	250 mL Poly	NP
7	291807	Yes	N/A	Yes	250 mL Poly	NP

2nd Review

Were all containers scanned into storage/lab? Initials TD

Are barcode labels on correct containers? (Yes) / No

Are all Flashpoint stickers attached/container ID # circled? Yes / No / NA

Are all Hex Chrome stickers attached? Yes / No / NA

Are all QC stickers attached? Yes / No / NA

Are VOA stickers attached if bubbles noted? Yes / No / NA

Completed By: Taylor Davis Date & Time: 5/13/22 1846

Reviewed By: [signature] Date & Time: 5.13.22 1648

ESS Laboratory

Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 220534.

Turn Time	5	Days
Regulatory State	Massachusetts	
Is this project for any of the following?:	○ CT RCP ○ MA MCP ○ RGP	

Reporting Limits

Electonic Deliverables ☐ Data Checker ☐ Excel ☐ Other (Please Specify →)

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB

	Address		
Julianne Marrion	250 Apollo Dr		
City	**State**	**Zip Code**	**PO #**
Chelmsford	MA	01824	
Telephone Number	**FAX Number**	**Email Address**	
978-905-2419		julianne.marrion@aecom.com	

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: Total Nitrogen	Nitrate, Nitrite	Lab Filter Dissolved Fe, Mn	DOC											
1	5.13.22	1040	Grab	Ground Water	DU-5-34	X	X	X	X											
2	↓	1010	Grab	Ground Water	DU-5-67	X	X	X	X											
3		1000	Grab	Ground Water	DU-5-100	X	X	X	X											
4		1250	Grab	Ground Water	DU-6-33	X	X	X	X											
5		1200	Grab	Ground Water	DU-6-67	X	X	X	X											
6		1155	Grab	Ground Water	DU-6-100	X	X	X	X											
7	↓	1355	Grab	Ground Water	PZ-1-105	X	X	X	X											
			Grab	Ground Water																
			Grab	Ground Water																
			Grab	Ground Water																

Container Type:	AC-Air Cassette	AG-Amber Glass	B-BOD Bottle	C-Cubitainer	J-Jar	O-Other	P-Poly	S-Sterile	V-Vial	P	P	P	AG	V						
Container Volume:	1-100 mL	2-2.5 gal	3-250 mL	4-300 mL	5-500 mL	6-1L	7-VOA	8-2 oz	9-4 oz	10-8 oz	11-Other*	6	3	3	3	7				
Preservation Code:	1-Non Preserved	2-HCl	3-H2SO4	4-HNO3	5-NaOH	6-Methanol	7-Na2S2O3	8-ZnAce, NaOH	9-NH4Cl	10-DI H2O	11-Other*	3	1	1	1	2				
											Number of Containers per Sample:	1	1	1	1	2				

Laboratory Use Only

Cooler Present: Yes ○ Drop Off
Seals Intact: ○ Pickup
Cooler Temperature: 2-1 °C IR

Sampled by : C. Hayden

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
C. Hayden 5.13.22 1630	5/13/22 16:24	5/13/22 18:06	Taylor Davis 1806 5/13/22
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 22E0680

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 1:19 pm, May 26, 2022

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0680

SAMPLE RECEIPT

The following samples were received on May 18, 2022 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
22E0680-01	BR-5-37	Ground Water	200.7, 353.2, 4500N, 5310B
22E0680-02	BR-5-64	Ground Water	200.7, 353.2, 4500N, 5310B
22E0680-03	BR-5-90	Ground Water	200.7, 353.2, 4500N, 5310B
22E0680-04	BR-6-56	Ground Water	200.7, 353.2, 4500N, 5310B
22E0680-05	BR-6-78	Ground Water	200.7, 353.2, 4500N, 5310B

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0680

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0680

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-5-37
Date Sampled: 05/18/22 13:30
Percent Solids: N/A

ESS Laboratory Work Order: 22E0680
ESS Laboratory Sample ID: 22E0680-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/19/22 14:20	10	10	DE21831
Manganese	**0.075** (0.020)		200.7		1	KJK	05/19/22 14:20	10	10	DE21831

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-5-37
Date Sampled: 05/18/22 13:30
Percent Solids: N/A

ESS Laboratory Work Order: 22E0680
ESS Laboratory Sample ID: 22E0680-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**3.47** (0.500)		5310B		1	CCP	05/23/22 22:08	mg/L	[CALC]
Nitrate as N	**0.731** (0.0300)		353.2		1	JLK	05/19/22 19:24	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/19/22 17:03	mg/L	DE21933
Total Nitrogen	**1.08** (0.200)		4500N		1	JLK	05/23/22 15:36	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-5-64
Date Sampled: 05/18/22 13:00
Percent Solids: N/A

ESS Laboratory Work Order: 22E0680
ESS Laboratory Sample ID: 22E0680-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/19/22 14:23	10	10	DE21831
Manganese	ND (0.020)		200.7		1	KJK	05/19/22 14:23	10	10	DE21831

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-5-64
Date Sampled: 05/18/22 13:00
Percent Solids: N/A

ESS Laboratory Work Order: 22E0680
ESS Laboratory Sample ID: 22E0680-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.938** (0.500)		5310B		1	CCP	05/23/22 22:45	mg/L	[CALC]
Nitrate as N	**1.10** (0.0500)		353.2		2	JLK	05/19/22 19:25	mg/L	[CALC]
Nitrite as N	**0.011** (0.010)		353.2		1	JLK	05/19/22 17:04	mg/L	DE21933
Total Nitrogen	**1.11** (0.200)		4500N		2	JLK	05/23/22 15:36	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-5-90
Date Sampled: 05/18/22 13:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0680
ESS Laboratory Sample ID: 22E0680-03
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**3.28** (0.100)		200.7		1	KJK	05/19/22 14:32	10	10	DE21831
Manganese	**0.490** (0.020)		200.7		1	KJK	05/19/22 14:32	10	10	DE21831

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-5-90
Date Sampled: 05/18/22 13:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0680
ESS Laboratory Sample ID: 22E0680-03
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.05** (0.500)		5310B		1	CCP	05/23/22 22:57	mg/L	[CALC]
Nitrate as N	ND (0.0300)		353.2		1	JLK	05/19/22 19:26	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/19/22 17:05	mg/L	DE21933
Total Nitrogen	ND (0.200)		4500N		1	JLK	05/25/22 14:57	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-6-56
Date Sampled: 05/18/22 15:10
Percent Solids: N/A

ESS Laboratory Work Order: 22E0680
ESS Laboratory Sample ID: 22E0680-04
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.119** (0.100)		200.7		1	KJK	05/19/22 14:34	10	10	DE21831
Manganese	ND (0.020)		200.7		1	KJK	05/19/22 14:34	10	10	DE21831

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-6-56
Date Sampled: 05/18/22 15:10
Percent Solids: N/A

ESS Laboratory Work Order: 22E0680
ESS Laboratory Sample ID: 22E0680-04
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.03** (0.500)		5310B		1	CCP	05/23/22 23:09	mg/L	[CALC]
Nitrate as N	**1.34** (0.110)		353.2		5	JLK	05/19/22 19:26	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/19/22 17:06	mg/L	DE21933
Total Nitrogen	**1.34** (0.200)		4500N		5	JLK	05/25/22 15:00	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-6-78
Date Sampled: 05/18/22 15:15
Percent Solids: N/A

ESS Laboratory Work Order: 22E0680
ESS Laboratory Sample ID: 22E0680-05
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/19/22 14:40	10	10	DE21831
Manganese	**0.027** (0.020)		200.7		1	KJK	05/19/22 14:40	10	10	DE21831

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-6-78
Date Sampled: 05/18/22 15:15
Percent Solids: N/A

ESS Laboratory Work Order: 22E0680
ESS Laboratory Sample ID: 22E0680-05
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.889** (0.500)		5310B		1	CCP	05/23/22 23:21	mg/L	[CALC]
Nitrate as N	**2.21** (0.110)		353.2		5	JLK	05/19/22 19:27	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	05/19/22 17:06	mg/L	DE21933
Total Nitrogen	**2.21** (0.200)		4500N		5	JLK	05/25/22 15:01	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0680

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DE21831 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.53		mg/L	2.500		101	80-120			
Manganese	0.514		mg/L	0.5000		103	80-120			
Classical Chemistry										
Batch DE21933 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.250		mg/L	0.2497		100	90-110			
Nitrite as N	0.250		mg/L	0.2497		100	90-110			
Batch DE21934 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.509		mg/L	0.5000		102	90-110			
Nitrate/Nitrite as N	0.509		mg/L	0.5000		102	90-110			
Batch DE22034 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	12.8	2.00	mg/L	13.20		97	80-120			
Batch DE22051 - General Preparation										
Blank										
Dissolved Organic Carbon (1)	ND	0.500	mg/L							
Dissolved Organic Carbon (2)	ND	0.500	mg/L							
LCS										
Dissolved Organic Carbon (1)	5.11	0.500	mg/L	5.000		102	80-120			
Dissolved Organic Carbon (2)	5.23	0.500	mg/L	5.000		105	80-120			
LCS Dup										
Dissolved Organic Carbon (1)	5.05	0.500	mg/L	5.000		101	80-120	1	20	
Dissolved Organic Carbon (2)	5.09	0.500	mg/L	5.000		102	80-120	3	20	
Batch DE22335 - TKN Prep										

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0680

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Classical Chemistry										
Batch DE22335 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	13.9	2.00	mg/L	13.20		105	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0680

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0680

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ESS Courier

ESS Project ID: 22E0680
Date Received: 5/18/2022
Project Due Date: 5/25/2022
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 3.7 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** Yes / No / NA
10. Were any analyses received outside of hold time? Yes / No

11. Any Subcontracting needed? Yes / No
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / No
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA
13. Are the samples properly preserved? Yes / No
    a. If metals preserved upon receipt: Date: Time: By/Acid Lot#:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

14. Was there a need to contact Project Manager? Yes / No
    a. Was there a need to contact the client? Yes / No
    Who was contacted? Date: Time: By:

Resolution:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	293636	Yes	N/A	Yes	1L Poly	H2SO4	
1	293641	Yes	N/A	Yes	250 mL Poly	NP	
1	293642	Yes	N/A	Yes	250 mL Poly	NP	
1	293651	Yes	N/A	Yes	250 mL Amber	NP	
2	293637	Yes	N/A	Yes	1L Poly	H2SO4	
2	293643	Yes	N/A	Yes	250 mL Poly	NP	
2	293644	Yes	N/A	Yes	250 mL Poly	NP	
2	293652	Yes	N/A	Yes	250 mL Amber	NP	
3	293638	Yes	N/A	Yes	1L Poly	H2SO4	
3	293645	Yes	N/A	Yes	250 mL Poly	NP	
3	293646	Yes	N/A	Yes	250 mL Poly	NP	
3	293653	Yes	N/A	Yes	250 mL Amber	NP	
4	293639	Yes	N/A	Yes	1L Poly	H2SO4	
4	293647	Yes	N/A	Yes	250 mL Poly	NP	
4	293648	Yes	N/A	Yes	250 mL Poly	NP	
4	293654	Yes	N/A	Yes	250 mL Amber	NP	
5	293640	Yes	N/A	Yes	1L Poly	H2SO4	

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

ESS Project ID: 22E0680
Date Received: 5/18/2022

5	293649	Yes	N/A	Yes	250 mL Poly	NP
5	293650	Yes	N/A	Yes	250 mL Poly	NP
5	293655	Yes	N/A	Yes	250 mL Amber	NP

2nd Review

Were all containers scanned into storage/lab? Initials TD

Are barcode labels on correct containers? Yes / No

Are all Flashpoint stickers attached/container ID # circled? Yes / No / NA

Are all Hex Chrome stickers attached? Yes / No / NA

Are all QC stickers attached? Yes / No / NA

Are VOA stickers attached if bubbles noted? Yes / No / NA

Completed By: [signature] Date & Time: 5.18.22 1818

Reviewed By: [signature] Date & Time: 5.18.22 1900

ESS Laboratory

Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 22E0680

Turn Time	5	Days
Regulatory State	Massachusetts	
Is this project for any of the following?:	○ CT RCP ○ MA MCP ○ RGP	

Reporting Limits

Electonic Deliverables: ☐ Data Checker ☐ Excel ☐ Other (Please Specify →)

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB

Address			
Julianne Marrion	250 Apollo Dr		
City	**State**	**Zip Code**	**PO #**
Chelmsford	MA	01824	
Telephone Number	**FAX Number**	**Email Address**	
978-905-2419		julianne.marrion@aecom.com	

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: Total Nitrogen	Nitrate, Nitrite	Lab Filter Dissolved Fe, Mn	DOC													
1	5.18.22	1330	Grab	Ground Water	BL-5-37	X	X	X	X													
2	↓	1300	Grab	Ground Water	BL-5-64	↓	↓	↓	↓													
3		1305	Grab	Ground Water	BL-5-90																	
4		1510	Grab	Ground Water	BL-6-56																	
5	↓	1515	Grab	Ground Water	BL-6-78	↓	↓	↓	↓													
			Grab	Ground Water																		
			Grab	Ground Water																		
			Grab	Ground Water																		
			Grab	Ground Water																		
			Grab	Ground Water																		

Container Type:	AC-Air Cassette	AG-Amber Glass	B-BOD Bottle	C-Cubitainer	J-Jar	O-Other	P-Poly	S-Sterile	V-Vial		P	P	P	AG	V							
Container Volume:	1-100 mL	2-2.5 gal	3-250 mL	4-300 mL	5-500 mL	6-1L	7-VOA	8-2 oz	9-4 oz	10-8 oz	11-Other*		6	3	3	3	7					
Preservation Code:	1-Non Preserved	2-HCl	3-H2SO4	4-HNO3	5-NaOH	6-Methanol	7-Na2S2O3	8-ZnAce, NaOH	9-NH4Cl	10-DI H2O	11-Other*		3	1	1	1	2					
												Number of Containers per Sample:	1	1	1	1	2					

Laboratory Use Only

Cooler Present: Yes ○ Drop Off
Seals Intact: ○ Pickup
Cooler Temperature: 3.7 °C / Ice

Sampled by : C. Toomey

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
Courtney Toomey 5-18-22 1640	5/18/22 16:40	5/18/22 18:01	1801 5/18/22
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 22E0752

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 3:03 pm, May 26, 2022

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0752

SAMPLE RECEIPT

The following samples were received on May 19, 2022 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
22E0752-01	BR-4-100	Ground Water	200.7, 353.2, 4500N, 5310B
22E0752-02	BR-4-68	Ground Water	200.7, 353.2, 4500N, 5310B
22E0752-03	BR-4-84	Ground Water	200.7, 353.2, 4500N, 5310B
22E0752-04	NA-2-88	Ground Water	200.7, 353.2, 4500N, 5310B

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0752

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0752

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-4-100
Date Sampled: 05/19/22 12:45
Percent Solids: N/A

ESS Laboratory Work Order: 22E0752
ESS Laboratory Sample ID: 22E0752-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/20/22 15:23	10	10	DE22028
Manganese	**0.210** (0.020)		200.7		1	KJK	05/20/22 15:23	10	10	DE22028

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-4-100
Date Sampled: 05/19/22 12:45
Percent Solids: N/A

ESS Laboratory Work Order: 22E0752
ESS Laboratory Sample ID: 22E0752-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.06** (0.500)		5310B		1	CCP	05/23/22 23:34	mg/L	[CALC]
Nitrate as N	**1.79** (0.110)		353.2		5	EAM	05/20/22 18:52	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/20/22 17:32	mg/L	DE22040
Total Nitrogen	**1.79** (0.200)		4500N		5	JLK	05/25/22 16:03	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-4-68
Date Sampled: 05/19/22 13:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0752
ESS Laboratory Sample ID: 22E0752-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	05/20/22 15:26	10	10	DE22028
Manganese	**0.118** (0.020)		200.7		1	KJK	05/20/22 15:26	10	10	DE22028

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-4-68
Date Sampled: 05/19/22 13:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0752
ESS Laboratory Sample ID: 22E0752-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**1.90** (0.500)		5310B		1	CCP	05/24/22 0:11	mg/L	[CALC]
Nitrate as N	**0.440** (0.0300)		353.2		1	EAM	05/20/22 18:36	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/20/22 17:33	mg/L	DE22040
Total Nitrogen	**0.643** (0.200)		4500N		1	JLK	05/25/22 16:06	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-4-84
Date Sampled: 05/19/22 14:15
Percent Solids: N/A

ESS Laboratory Work Order: 22E0752
ESS Laboratory Sample ID: 22E0752-03
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.141** (0.100)		200.7		1	KJK	05/20/22 15:28	10	10	DE22028
Manganese	**0.084** (0.020)		200.7		1	KJK	05/20/22 15:28	10	10	DE22028

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: BR-4-84
Date Sampled: 05/19/22 14:15
Percent Solids: N/A

ESS Laboratory Work Order: 22E0752
ESS Laboratory Sample ID: 22E0752-03
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.928** (0.500)		5310B		1	CCP	05/24/22 0:23	mg/L	[CALC]
Nitrate as N	**2.18** (0.110)		353.2		5	EAM	05/20/22 18:53	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/20/22 17:34	mg/L	DE22040
Total Nitrogen	**2.18** (0.200)		4500N		5	JLK	05/25/22 16:07	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: NA-2-88
Date Sampled: 05/19/22 15:25
Percent Solids: N/A

ESS Laboratory Work Order: 22E0752
ESS Laboratory Sample ID: 22E0752-04
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.927** (0.100)		200.7		1	KJK	05/20/22 15:30	10	10	DE22028
Manganese	**0.523** (0.020)		200.7		1	KJK	05/20/22 15:30	10	10	DE22028

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: NA-2-88
Date Sampled: 05/19/22 15:25
Percent Solids: N/A

ESS Laboratory Work Order: 22E0752
ESS Laboratory Sample ID: 22E0752-04
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.910** (0.500)		5310B		1	CCP	05/24/22 0:35	mg/L	[CALC]
Nitrate as N	ND (0.0300)		353.2		1	EAM	05/20/22 18:37	mg/L	[CALC]
Nitrite as N	**0.011** (0.010)		353.2		1	EAM	05/20/22 17:35	mg/L	DE22040
Total Nitrogen	ND (0.200)		4500N		1	JLK	05/25/22 16:07	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0752

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DE22028 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.53		mg/L	2.500		101	80-120			
Manganese	0.514		mg/L	0.5000		103	80-120			
Classical Chemistry										
Batch DE22040 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.261		mg/L	0.2497		105	90-110			
Nitrite as N	0.261		mg/L	0.2497		105	90-110			
Batch DE22041 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.503		mg/L	0.5000		101	90-110			
Nitrate/Nitrite as N	0.503		mg/L	0.5000		101	90-110			
Batch DE22051 - General Preparation										
Blank										
Dissolved Organic Carbon (1)	ND	0.500	mg/L							
Dissolved Organic Carbon (2)	ND	0.500	mg/L							
LCS										
Dissolved Organic Carbon (1)	5.11	0.500	mg/L	5.000		102	80-120			
Dissolved Organic Carbon (2)	5.23	0.500	mg/L	5.000		105	80-120			
LCS Dup										
Dissolved Organic Carbon (1)	5.05	0.500	mg/L	5.000		101	80-120	1	20	
Dissolved Organic Carbon (2)	5.09	0.500	mg/L	5.000		102	80-120	3	20	
Batch DE22435 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	13.1	2.00	mg/L	13.20		99	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0752

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0752

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ESS Courier

ESS Project ID: 22E0752
Date Received: 5/19/2022
Project Due Date: 5/26/2022
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 4.6 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** (Yes) / No / NA
10. Were any analyses received outside of hold time? Yes / (No)

11. Any Subcontracting needed? Yes / (No)
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / (No)
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA

13. Are the samples properly preserved? (Yes) / No
    a. If metals preserved upon receipt: Date: Time: By/Acid Lot#:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

14. Was there a need to contact Project Manager? Yes / (No)
    a. Was there a need to contact the client? Yes / (No)
    Who was contacted? Date: Time: By:

Resolution:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	294406	Yes	N/A	Yes	1L Poly	H2SO4	
1	294410	Yes	N/A	Yes	250 mL Amber	NP	
1	294414	Yes	N/A	Yes	250 mL Poly	NP	
1	294415	Yes	N/A	Yes	250 mL Poly	NP	
2	294407	Yes	N/A	Yes	1L Poly	H2SO4	
2	294411	Yes	N/A	Yes	250 mL Amber	NP	
2	294416	Yes	N/A	Yes	250 mL Poly	NP	
2	294417	Yes	N/A	Yes	250 mL Poly	NP	
3	294408	Yes	N/A	Yes	1L Poly	H2SO4	
3	294412	Yes	N/A	Yes	250 mL Amber	NP	
3	294418	Yes	N/A	Yes	250 mL Poly	NP	
3	294419	Yes	N/A	Yes	250 mL Poly	NP	
4	294409	Yes	N/A	Yes	1L Poly	H2SO4	
4	294413	Yes	N/A	Yes	250 mL Amber	NP	
4	294420	Yes	N/A	Yes	250 mL Poly	NP	
4	294421	Yes	N/A	Yes	250 mL Poly	NP	

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

ESS Project ID: 22E0752
Date Received: 5/19/2022

2nd Review
Were all containers scanned into storage/lab? Initials TD
Are barcode labels on correct containers? Yes / No
Are all Flashpoint stickers attached/container ID # circled? Yes / No / NA
Are all Hex Chrome stickers attached? Yes / No / NA
Are all QC stickers attached? Yes / No / NA
Are VOA stickers attached if bubbles noted? Yes / No / NA

Completed By: [signature] Date & Time: 5/19/22 1828.
Reviewed By: [signature] Date & Time: 5.19.22 1916

ESS Laboratory

Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 22E0752

Turn Time: 5 Days
Regulatory State: Massachusetts
Is this project for any of the following?: ○ CT RCP ○ MA MCP ○ RGP
Reporting Limits
Electonic Deliverables: ☐ Data Checker ☐ Excel ☐ Other (Please Specify →)

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB

Julianne Marrion	Address: 250 Apollo Dr	
City: Chelmsford	State: MA	Zip Code: 01824 / PO #:
Telephone Number: 978-905-2419	FAX Number:	Email Address: julianne.marrion@aecom.com

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: Total Nitrogen	Nitrate, Nitrite	Lab Filter Dissolved Fe, Mn	DOC														
1	5-19-22	1245	Grab	Ground Water	BR-4-100	x	x	x	x														
2	5-19-22	1305	Grab	Ground Water	BR-4-68																		
3	5-19-22	1415	Grab	Ground Water	BR-4-84																		
4	5-19-22	1525	Grab	Ground Water	NA-2-88																		
			Grab	Ground Water																			
			Grab	Ground Water																			
			Grab	Ground Water																			
			Grab	Ground Water																			
			Grab	Ground Water																			
			Grab	Ground Water																			

Container Type:	AC-Air Cassette	AG-Amber Glass	B-BOD Bottle	C-Cubitainer	J-Jar	O-Other	P-Poly	S-Sterile	V-Vial	P	P	P	AG	V									
Container Volume:	1-100 mL	2-2.5 gal	3-250 mL	4-300 mL	5-500 mL	6-1L	7-VOA	8-2 oz	9-4 oz	10-8 oz	11-Other*	6	3	3	3	7							
Preservation Code:	1-Non Preserved	2-HCl	3-H2SO4	4-HNO3	5-NaOH	6-Methanol	7-Na2S2O3	8-ZnAce, NaOH	9-NH4Cl	10-DI H2O	11-Other*	3	1	1	1	2							
											Number of Containers per Sample:	1	1	1	1	2							

Laboratory Use Only

Cooler Present: yes ○ Drop Off
Seals Intact: ○ Pickup
Cooler Temperature: 4.6 °C / Ice

Sampled by : C. Tormey

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
Courtney Tormey 5/19/22 1630	5/19/22 16:54	5/19/22 17:56	Taylor Davis 1756 5/19/22
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

CERTIFICATE OF ANALYSIS

Julianne Marrion
AECOM Environment - ENSR
9 Jonathan Bourne Dr
Pocasset, MA 02559

RE: Orleans MA (60476644)
ESS Laboratory Work Order Number: 22E0823

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 4:42 pm, May 27, 2022

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0823

SAMPLE RECEIPT

The following samples were received on May 20, 2022 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
22E0823-01	NA-2-55	Ground Water	200.7, 353.2, 4500N, 5310B
22E0823-02	NA-2-22	Ground Water	200.7, 353.2, 4500N, 5310B

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0823

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0823

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH
MADEP 18-2.1 - VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035A - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: NA-2-55
Date Sampled: 05/20/22 11:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0823
ESS Laboratory Sample ID: 22E0823-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**0.837** (0.100)		200.7		1	KJK	05/25/22 22:11	10	10	DE22443
Manganese	**1.56** (0.020)		200.7		1	KJK	05/25/22 22:11	10	10	DE22443

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: NA-2-55
Date Sampled: 05/20/22 11:05
Percent Solids: N/A

ESS Laboratory Work Order: 22E0823
ESS Laboratory Sample ID: 22E0823-01
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**0.523** (0.500)		5310B		1	CCP	05/24/22 14:58	mg/L	[CALC]
Nitrate as N	ND (0.0300)		353.2		1	EAM	05/20/22 20:04	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	EAM	05/20/22 19:34	mg/L	DE22047
Total Nitrogen	**0.203** (0.200)		4500N		1	JLK	05/25/22 16:18	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: NA-2-22
Date Sampled: 05/20/22 11:45
Percent Solids: N/A

ESS Laboratory Work Order: 22E0823
ESS Laboratory Sample ID: 22E0823-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest

All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**4.01** (0.100)		200.7		1	KJK	05/25/22 22:13	10	10	DE22443
Manganese	**0.117** (0.020)		200.7		1	KJK	05/25/22 22:13	10	10	DE22443

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: NA-2-22
Date Sampled: 05/20/22 11:45
Percent Solids: N/A

ESS Laboratory Work Order: 22E0823
ESS Laboratory Sample ID: 22E0823-02
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Dissolved Organic Carbon (Average)	**11.0** (1.00)		5310B		2	CCP	05/24/22 1:00	mg/L	[CALC]
Nitrate as N	ND (0.0300)		353.2		1	EAM	05/20/22 20:10	mg/L	[CALC]
Nitrite as N	**0.011** (0.010)		353.2		1	EAM	05/20/22 19:40	mg/L	DE22047
Total Nitrogen	**0.597** (0.200)		4500N		1	JLK	05/25/22 16:19	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0823

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch DE22443 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.50		mg/L	2.500		100	80-120			
Manganese	0.503		mg/L	0.5000		101	80-120			
Classical Chemistry										
Batch DE22047 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.262	0.010	mg/L	0.2497		105	90-110			
Nitrite as N	0.262	0.010	mg/L	0.2497		105	90-110			
Batch DE22048 - General Preparation										
Blank										
Nitrate/Nitrite as N	ND	0.020	mg/L							
Nitrate/Nitrite as N	ND	0.020	mg/L							
LCS										
Nitrate/Nitrite as N	0.508	0.020	mg/L	0.5000		102	90-110			
Nitrate/Nitrite as N	0.508	0.020	mg/L	0.5000		102	90-110			
Batch DE22051 - General Preparation										
Blank										
Dissolved Organic Carbon (1)	ND	0.500	mg/L							
Dissolved Organic Carbon (2)	ND	0.500	mg/L							
LCS										
Dissolved Organic Carbon (1)	5.11	0.500	mg/L	5.000		102	80-120			
Dissolved Organic Carbon (2)	5.23	0.500	mg/L	5.000		105	80-120			
LCS Dup										
Dissolved Organic Carbon (1)	5.05	0.500	mg/L	5.000		101	80-120	1	20	
Dissolved Organic Carbon (2)	5.09	0.500	mg/L	5.000		102	80-120	3	20	
Batch DE22435 - TKN Prep										
Blank										
Total Kjeldahl Nitrogen as N	ND	0.20	mg/L							
LCS										
Total Kjeldahl Nitrogen as N	13.1	2.00	mg/L	13.20		99	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0823

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit
MF	Membrane Filtration
MPN	Most Probable Number
TNTC	Too numerous to Count
CFU	Colony Forming Units

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 22E0823

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

Shipped/Delivered Via: ESS Courier

ESS Project ID: 22E0823
Date Received: 5/20/2022
Project Due Date: 5/27/2022
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 3.3 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** (Yes) / No / NA
10. Were any analyses received outside of hold time? Yes / (No)

11. Any Subcontracting needed? Yes / (No)
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / (No)
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA

13. Are the samples properly preserved? (Yes) / No
    a. If metals preserved upon receipt: Date: Time: By/Acid Lot#:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

14. Was there a need to contact Project Manager? Yes / (No)
    a. Was there a need to contact the client? Yes / No
    Who was contacted? Date: Time: By:

Resolution:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
1	295295	Yes	N/A	Yes	1L Poly	H2SO4	
1	295297	Yes	N/A	Yes	250 mL Amber	NP	
1	295299	Yes	N/A	Yes	250 mL Poly	NP	
1	295300	Yes	N/A	Yes	250 mL Poly	NP	
2	295296	Yes	N/A	Yes	1L Poly	H2SO4	
2	295298	Yes	N/A	Yes	250 mL Amber	NP	
2	295301	Yes	N/A	Yes	250 mL Poly	NP	
2	295302	Yes	N/A	Yes	250 mL Poly	NP	

2nd Review
Were all containers scanned into storage/lab? Initials: [illegible]
Are barcode labels on correct containers? (Yes) / No
Are all Flashpoint stickers attached/container ID # circled? Yes / No / NA
Are all Hex Chrome stickers attached? Yes / No / NA
Are all QC stickers attached? Yes / No / NA
Are VOA stickers attached if bubbles noted? Yes / No / NA

Completed

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB

ESS Project ID: 22E0823

Date Received: 5/20/2022

By: [signature] Date & Time: 5/20/22 1840

Reviewed By: [signature] Date & Time: 5/2022 1854

ESS Laboratory

Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 22E0823

Turn Time	5	Days
Regulatory State	Massachusetts	

Is this project for any of the following?: ○ CT RCP ○ MA MCP ○ RGP

Reporting Limits

Electonic Deliverables ☐ Data Checker ☐ Excel ☐ Other (Please Specify →)

Company Name	Project #	Project Name
AECOM	60476644	Orleans PRB

Address			
Julianne Marrion	250 Apollo Dr		
City	State	Zip Code	PO #
Chelmsford	MA	01824	
Telephone Number	FAX Number	Email Address	
978-905-2419		julianne.marrion@aecom.com	

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: Total Nitrogen	Nitrate, Nitrite	Lab Filter Dissolved Fe, Mn	DOC												
1	5.10.22	1105	Grab	Ground Water	NA-2-55	X	X	X	X												
2	5.10.22	1145	Grab	Ground Water	NA-2-22	X	X	X	X												
			Grab	Ground Water																	
			Grab	Ground Water																	
			Grab	Ground Water																	
			Grab	Ground Water																	
			Grab	Ground Water																	
			Grab	Ground Water																	
			Grab	Ground Water																	
			Grab	Ground Water																	

Container Type:	AC-Air Cassette	AG-Amber Glass	B-BOD Bottle	C-Cubitainer	J-Jar	O-Other	P-Poly	S-Sterile	V-Vial	P	P	P	AG	V							
Container Volume:	1-100 mL	2-2.5 gal	3-250 mL	4-300 mL	5-500 mL	6-1L	7-VOA	8-2 oz	9-4 oz	10-8 oz	11-Other*	6	3	3	3	7					
Preservation Code:	1-Non Preserved	2-HCl	3-H2SO4	4-HNO3	5-NaOH	6-Methanol	7-Na2S2O3	8-ZnAce, NaOH	9-NH4Cl	10-DI H2O	11-Other*	3	1	1	1	2					
											Number of Containers per Sample:	1	1	1	1	2					

Laboratory Use Only

Cooler Present: Yes ○ Drop Off
Seals Intact: ○ Pickup
Cooler Temperature: 3.3 °C / Ca

Sampled by : C Hayden

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
C Hayden 5.10.22 1630	5/20/22 16:44	5/20/22 18:32	1832 5/20/22
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

ATTACHMENT O

TECHNICAL MEMORANDUM – NITROGEN REDUCING BIOFILTERS FEASIBILITY

AECOM
9 Jonathan Bourne Drive
Pocasset, MA 02559
www.aecom.com

508.833.6950 tel
508.833.6951 fax

Memorandum

To	George Meservey, Director of Planning & Community Development Michael Domenica, PE, Program Manager
CC	Betsy Shreve, AICP, AECOM Project Director Paula Winchell, AECOM Reggie Donoghue, P.E., AECOM
Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 8 - NT Demonstration Projects** **Deliverable 8.1.2.A – Draft Nitrogen Reducing Barriers Feasibility**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	October 6, 2016

1. Introduction

The Orleans Water Quality Advisory Panel, or OWQAP, was convened to achieve consensus and build widespread community support for a customized, affordable water quality management plan for the Town of Orleans. The panel consisted 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 starting in July 2014, 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. As discussed in further detail below in Section 2c, a Hybrid Plan was developed through an iterative process and included specific sites for the use of NT nitrogen removal technologies, including FCW, permeable reactive barriers, aquaculture and coastal habitat restoration. Once the feasibility of using NT technologies as part of the Town's nutrient management strategy was established, the OWQAP decided that the final Consensus Plan would not specify exact site locations but instead focus on overall quantities of NT technologies needed to remove the appropriate mass of nitrogen at the watershed level.

The resulting map entitled "Conceptual Approach to Meet Orleans Water Quality Goals (March 2015)" shows the agreed upon water quality management plan. Since the preparation of the map, Nitrogen Reducing Barriers (NRBs) were included in the toolbox of NT technologies that would be implemented in order to achieve water quality goals. The locations of the NRB demonstration sites have not yet been identified.

This Technical Memorandum outlines the proposed Site Characterization Evaluation and Work Plan for determining the feasibility of NRBs.

2. Goals and Objectives of NRB Demonstration Project

The goal of this demonstration project is to evaluate the potential to use NRBs to:

- Reduce nitrogen discharge to the environment at its source;
- Determine if an NRB can function as a viable, maintenance free, component of an onsite sewage disposal system;
- Assess local ground water quality and ecological benefits; and
- Provide a case study to guide siting, design and monitoring of future projects.

The pilot projects will be built as repairs to existing failed sewage disposal systems and will be monitored for five years from the date that the system is placed into service.

The immediate objectives of the proposed NRB demonstration project are to:

- Realize associated ecological and socioeconomic benefits;
- Install the NRBs as an integral component of an upgraded sewage disposal system;
- Monitor the performance of the NRBs to reduce nitrogen discharged to groundwater; and
- Evaluate uncertainties associated with the local climate and environmental conditions;
- Infer quantitative decisions about the value of NRBs at meeting the long term goals of the Town of Orleans in reducing nitrogen in its water resources.

3. Site Characterization Evaluation

A. General

The Site Characterization and Evaluation documents the process that will be used to identify, evaluate, rate, and rank demonstration sites to test the efficacy of NRBs to remove nitrogen from sewage disposal system discharges within the Town of Orleans. This Memorandum includes the following:

- Description of the proposed site identification plan that will be based on coordination between AECOM and the Orleans BOH in order to identify up to four potential demonstration sites;
- Next steps taken in the process of evaluating the demonstration sites;
- Review of available data to understand current site conditions and evaluate potential demonstration sites; and
- Methods that will be used to evaluate and choose potential sites for NRB installations Evaluation, rating and ranking of sites based on the site selection matrix and criteria.

In addition, key terms are defined including the categories of data that were evaluated. The site selection criteria and rating system used to assess potential demonstration sites are also explained.

The purpose of this documentation is to provide a transparent and objective assessment of the methods that will be employed to identify possible locations in Orleans to site NRB Non-Traditional technology demonstration projects. The assessment will be used to select the best possible sites for preliminary engineering, which will include drawings, preliminary specifications, cost estimates, funding sources and monitoring plans.

B. Key Nitrogen Reducing Biofilter Design Features

To establish a consistent meaning of NRBs in the context of this Technical Memorandum, this term is defined as follows: An NRB is constructed as part of a sewage disposal system soil absorption field that is comprised of a sand based "nitrification layer" underlain by a "denitrification layer" of sand mixed with finely ground wood.

The NRB is implemented following a conventional septic tank. Effluent from the septic tank flows by gravity to a pump chamber that will intermittently dose the Soil Absorption field with a low pressure distribution system. The NRB is incorporated into the design of the soil absorption field. As Septic tank effluent passes through the Soil treatment area the nitrogen in the system effluent is reduced.

The following core design principals that will be followed in the design of the NRBs are to:

- Utilize natural treatment technologies where possible;
- Minimize energy use and mechanical system complexity;
- Incorporate the NRBs into sewage disposal systems that are upgrades to existing systems that are determined to be in a state of failure.
- Incorporate educational and interpretive value into the system; and
- Develop systems that are easy to maintain and operate to enhance long-term viability.

NRBs typically consist of a layer of sandy soils overlying a layer of mixed with finely ground wood that is dosed by a low pressure distribution system. NRBs remove nitrogen from septic tank effluent via the two step microbial processes of nitrification and denitrification. In tests, NRBs have shown an ability to achieve a high percentage of nitrogen removal (up to 90%), as well as significant attenuation within the nitrifying layer of pathogens, pharmaceuticals, and personal care products.

The removal of nitrogen in a NRB involves two steps: (1) a nitrification step in which ammonia and reduced organic nitrogen is septic tank effluent is converted to nitrate in an unsaturated, oxygen (O2) rich sand layer; and (2) a denitrification step in which nitrate is converted to nitrogen gas in a semi saturated to saturated, O2-limited sand plus lignocellulose (wood chips or sawdust) layer.

The NRB will be constructed as a horizontal later in a multi layered soil Absorption field system.

C. Proposed Site Identification Methodology

AECOM will coordinate with the Orleans Health Agent to identify up to four sites that would be candidates for installing an NRB as an integral part of a sewage disposal system upgrade. The following criteria will be used to help choose the candidate sites:

- The sewage disposal system that serves the facility shall be considered failed under State and local regulations (310 CMR 15.303, and Chapter 185, Article III, § 185-17.2 Definitions, of the Orleans Board of Health Regulations;

- There is no proposed increase in the number of bedrooms or the tabular sewage flow from the facility that will be served by the sewage disposal system upgrade;

- The sewage disposal system will not need variances from the required groundwater separation requirements under local and state regulations;

- The proposed sewage disposal system upgrade site will be greater than 100' from wetlands as identified under the MA Wetlands Protection Act and the Orleans Wetlands Protection By-Law;

- The proposed site will be located outside of a FEMA mapped 100 year flood zone;

- The property has sufficient area to install the sewage disposal system upgrade without dimensional variances from Title 5;

- The site and property owner comply with the requirements of the Approval Letter issued by MassDEP for Piloting of the Non Traditional technology; and

- The property owner agrees to allow access to the site for sampling and monitoring purposes.

D. Definition of Failure of a Septic System under the Town of Orleans Board of Health Regulations (Chapter 185, Article III, § 185-17.2 Definitions)

Any Septic System shall be considered to be failed when any of the following are met:

- Any component does not function as intended;

- The system causes effluent to be discharged to the surface of the ground, stream, or other watercourse;

- Any component is pumped to remove septage more than twice in any 12 month period except grease traps which may be pumped in accordance with Title 5, 310,15.351 (2) and systems serving laundromats, restaurants, food service or other establishments determined to be a high water user by the Board of Health and which is pumped frequently. Septic Systems serving high water uses shall be reviewed on a case by case basis with respect to its failure criteria;

- Any of its components consist of a privy, cesspool, or a converted cesspool, which has been identified during an inspection for the sale of the property, a change of use, or for a building permit resulting in an increase in flow, increase in square footage, or a change of footprint;

- The Soil Absorption System lacks a two foot protective zone between the bottom of the system and the maximum groundwater elevation; and

- A system has any other problem as defined by the Board of Health or it's agent which fails to protect the public health and safety and the environment.

4. NRB Work Plan

A. Purpose

The NRB Work Plan sets forth the preliminary design of the NRB, including the project components, sequencing of subtasks, the equipment, labor and other resources required to construct the NRB, and a preliminary cost estimate. The NRB Work Plan also sets forth a draft monitoring and maintenance plan, along with potential regulatory requirements and funding sources.

The purpose of the NRB work plan is to provide to the Town available information about NRB's to aid in the decision making process about whether or not to undertake the next steps towards the implementation of a demonstration project.

1) Recommended Site Location

AECOM will coordinate with the Orleans Health Agent to identify up to four sites that would be candidates for installing an NRB as an integral part of a sewage disposal system upgrade. The following criteria will be used to help choose the candidate sites:

- The sewage disposal system that serves the facility shall be considered failed under State and local regulations (310 CMR 15.303, and Chapter 185, Article III, § 185-17.2 Definitions, of the Orleans Board of Health Regulations;
- There is no proposed increase in the number of bedrooms or the sewage flow from the facility that will be served by the sewage disposal system upgrade;
- The sewage disposal system will not need variances from the required groundwater separation requirements under local and state regulations;
- The proposed sewage disposal system upgrade site will be greater than 100' from wetlands as identified under the MA Wetlands Protection Act and the Orleans Wetlands Protection By-Law;

The proposed site will be located outside of a FEMA mapped 100 year flood zone;

- The property has sufficient area to install the sewage disposal system upgrade without dimensional variances from Title 5;
- The site and property owner comply with the requirements of the Approval Letter issued by MassDEP for Piloting of the Non Traditional technology and,
- The property owner agrees in writing to allow access to the site for sampling and monitoring purposes.

2) NRB Attributes

NRBs are a horizontal Permeable Reactive Barrier that typically consist of a layer of sandy soils overlying a layer of sand mixed with finely ground wood that is dosed with septic tank effluent by a low pressure distribution system. NRBs remove nitrogen from septic tank effluent via the two step microbial processes of nitrification and denitrification. In tests, NRBs have shown an ability to achieve a high percentage of nitrogen removal (up to 90%), as well as significant attenuation within the nitrifying layer of pathogens, pharmaceuticals, and personal care products.

The removal of nitrogen in a NRB involves two steps: 1) a nitrification step in which ammonia and reduced organic nitrogen is septic tank effluent is converted to nitrate in an unsaturated, oxygen (O2) rich sand layer, followed by 2) a denitrification step in which nitrate is converted to nitrogen gas in a semi saturated to saturated, O2-limited sand plus lignocellulose (wood chips or sawdust) layer.

Under certain conditions, NRB have been shown to meet the following core design principals:

- Utilize natural, biological treatment technologies;
- Minimize energy use and mechanical system complexity; and,
- Incorporate educational and interpretive value into the system.

The key feature of NRBs is that they can easily be incorporated into the design of a sewage disposal system soil absorption area. With the exception of the need to pressure dose the soil absorption area, no complex mechanical components are required for the NRB system.

3) Information Gaps to be addressed in Spring/Summer 2016 prior to full scale implementation.

To implement the NRB Demonstration Project and allow for the most effective siting, the following additional data and permits will need to be acquired in order to supplement the initial research:

- Coordinate with the OBOH to help identify up to four properties with failing on-site sewage disposal systems that are candidates for the demonstration project.
- Research and coordinate with the Barnstable County Department of Health and Environment (BCDHE) relative to NRB design and specifications;
- Coordinate with the OBOH and Barnstable County Department of Health and Environment (BCDHE) relative to the application for grant monies for financial assistance in implementing the NRB Demonstration Projects:

- Prepare and file an application with Mass DEP for Piloting Approval for each of the NRB Demonstration Project sites;
- Apply to the OBOH for approval of each installation;
- Prepare and file Disposal Works Construction Permits for each site with the OBOH.

The BCDHE is in the process of implementing several demonstration projects on Cape Cod and additional performance and design data is expected to be available in the spring of 2017.

B. Site Specific Assessment for Preliminary Design

Site specific conditions will be used for the preliminary design of the NRB demonstration projects Sewage flows; soil conditions, groundwater elevations, available undeveloped site area, and other site specific conditions will be used as a basis for the preliminary design of the demonstration projects.

C. Preliminary Design

1) Site Configuration

The site configuration will be determined once the candidate sites have been chosen.

2) Project Components

- Septic Tank - The existing septic tank, if possible, will be utilized in the design of the sewage disposal system upgrade. If the existing septic tank is found to be structurally sound and meets code requirements relative to tank capacity, it may be retained for the upgrade. New inlet and outlet tees, and a gas baffle, may need to be fitted to the tank. If it is determined that a new septic tank is required, the precast concrete tank will be sized in accordance with code requirements. If determined appropriate for the design, a two compartment tank may be utilized. The second compartment would be used as a dosing tank for the low pressure distribution system.

- Dosing Tank – If not incorporated into the design of a new septic tank, a separate precast concrete tank will be required for the placement of a pump(s) for the low pressure dosing of the soil absorption area. The tank will house the pump(s) and control floats. The pumps will be installed with a timed dose control system in order to meter the effluent flow to the soil absorption area.

- Soil Absorption Area and Nitrogen Reducing Biofilter – The soil absorption area will be designed to incorporate an NRB into the system. A typical residential soil absorption area is constructed with ¾" to 1-1/2" stone that is gravity dosed. The soil absorption area that includes an NRB is comprised of a sand based "nitrification layer" underlain by a "denitrification layer" of sand mixed with finely ground wood. The system is installed following a standard septic tank and pump chamber that intermittently doses a low pressure distribution system that includes a GeoMat system above the sand layer to ensure even distribution of the effluent over the entire soil absorption area.

- Monitor Wells – Monitor wells will be installed in order to determine groundwater flow direction and baseline groundwater quality information, as well as for sampling the groundwater over a period of five years from when the system is put into service.

3) Sequencing of Subtasks

To implement the NRB demonstration projects, the following tasks will be undertaken:

- Coordinate with property owners, the OBOH, and the BCDHE;
- Preliminary design for siting of the proposed demonstration projects;
- Topographic survey of the area of the proposed sewage disposal system upgrade and NRB sites;
- Premark the work area for Dig Safe and contact Dig Safe for utility marking;
- Completion of required soil evaluations at the site of the proposed Soil Absorption Systems;
- Prepare Soil Evaluation Reports and file the reports with the OBOH;
- Install monitor wells for water quality testing and to determine groundwater flow direction;
- Design of the sewage disposal system upgrades that include an NRB;
- Meet with BCDE to review the details of the NRB system designs;
- CAD drafting services for plan preparation;
- Professional oversight and plan certification;
- Prepare and file applications for OBH and MassDEP approval, and
- Implement the NRB demonstration project.

4) Labor resources needed to implement the NRB demonstration project:

Construction activities will be managed to limit disturbance to the project site and surrounding properties. A licensed firm, including an equipment operator and laborer(s) will be required for the NRB system installation. The implementation of the system will need to be inspected by the design engineer during installation.

5) Issues considered during preliminary design:

- What is the sewage flow for the installations;
- Is there sufficient area for installation of the soil absorption area;
- What relief, if any, will be required from local and state health regulations; and
- Soil and groundwater conditions.

5. Monitoring and Maintenance

A. General

The specific objective of this study is to evaluate the effectiveness the NRB demonstration projects in reducing the amount of nitrogen discharged to the environment. The monitoring and maintenance plan will include the following:

- Quarterly septic tank effluent and monitor well sampling and sample testing for a period of five years from the date of implementation of the systems;
- Quarterly measure temperature and pH of the septic tank effluent;
- Review test results and prepare an annual report on the performance of the systems;
- Attend an annual meeting with the Orleans BOH to report on the performance of the Demonstration Sites; and
- Any other testing required by the OBOH or the MassDEP Piloting Approval.

B. Water Quality Analysis

Water quality will be sampled using grab samples that are then sent to a lab for analysis.

Grab samples will be taken at monthly intervals. Grab samples will be taken from a drip pan lysimeter installed under the soil absorption area. The pH of the effluent will be recorded and the samples will then be sent to a qualified lab for analysis of the following constituents: total N, BOD_5 TSS and NO_3 or as required by the MassDEP Piloting Approval letter.

Grab samples will be taken from the monitor wells and tested for total N and $N0_{3,}$ or as required by the MassDEP Piloting Approval letter.

C. Maintenance Requirements

Visual inspection of the NRBs will occur on a quarterly basis. The main purpose of the maintenance inspections will be to confirm that the system is functioning as intended and to document any changes to the system or discharges to the surface. Maintenance activities will include the following:

- Inspect the site around the soil absorption area for signs or breakout of effluent to the surface;
- Measure the depth of ponding within the soil absorption area at the soil absorption area inspection port;
- Test the pump system alarm and log the reading on the pump run meter; and
- Perform the required effluent and groundwater sampling.

6. Project Cost Estimate

The estimated cost of the NRBs is approximately $30,000 per demonstration site. The cost estimate is based on the conceptual design, does not include maintenance and monitoring, and will be refined after additional engineering analyses are conducted. The cost estimate includes the following elements:

- Planning;
- System Design;
- Permitting;
- Implementation;
- Maintenance (not included); and
- Monitoring – Lab and In-Situ (not included).

7. Regulatory Considerations

The NRB Demonstration Project would require the approval of the Orleans Board of Health and Piloting Approval from MassDEP for each demonstration site. In addition, a Disposal Works Construction Permit will be required from the OBOH for the implementation of the demonstration projects.

8. Potential Funding Sources

Deliverables developed under Task 5 include an evaluation of general funding mechanisms for the overall wastewater management project, including options such as SRF funding, MassDEP 604b/319 grants, and USDA rural development grants.

In addition to the funding sources discussed as part of Task 5, potential funding sources available specifically for Nitrogen Reducing Biofilters were researched. Availability of these funding sources would be dependent on a successful application process, and also on application submittal deadlines as compared to the NRB DP schedule. Deadlines for many grants have passed or are imminent for the current calendar year, although submitting an application for a 2017 project might be feasible.

The potential funding sources and websites with additional information on each funding opportunity are listed in Table 1.

Table 1 - Potential Funding Sources for Nitrogen Reducing Biofilter Demonstration Projects

Grant Title	Website
US EPA Coastal Watershed Grants- Association to Preserve Cape Cod.	http://www.capecod.com/newscenter/coastal-watershed-grants-from-epa-to-benefit-4-cape-projects/ http://www.apcc.org/
MA Governors Budget Funds for Septic System Alternative Technology – Cape Cod Protection Collaborative	http://www.ccwpc.org/
604(b) Water Quality Management Planning Grant USEPA and MassDEP	http://www.mass.gov/eea/agencies/massdep/water/grants/watersheds-water-quality.html#2
319 Nonpoint Source Competitive Grant Program USEPA and MassDEP	http://www.mass.gov/eea/agencies/massdep/water/grants/watersheds-water-quality.html#3

9. Summary and Next Steps

The next step recommended before implementation of the NRB demonstration project is to conduct additional research regarding potential nitrogen removal rates that can be achieved by NRBs and design specifications. The results from test sites recently implemented by the Barnstable County Department of Health and Environment will help provide guidance for the design of the demonstration project.

10. References

Stony Brook University, June 2016. Nitrogen Removing Biofilters for Onsite Wastewater Treatment on Long Island: Current and Future Prospects. The New York State Center for Clean Water Technology.

Barnstable County Department of Health and Environment (Heufelder), 2016. Does Sawdust Have a Role In Saving Cape Cod's Bays?

ATTACHMENT P

ON-SITE DENITRIFICATION SYSTEMS SUMMARY REPORT

PLEASANT BAY ALLIANCE
Task 1A: On-Site Denitrification Systems Summary Report

Southeast New England Program (SNEP)
Grant - Regional Watershed Permit
Implementation Project for Pleasant Bay



Prepared by:

Horsley Witten Group, Inc.
90 Route 6a, Unit 1
Sandwich, MA 02563

July 28, 2020

PLEASANT BAY ALLIANCE
Task 1A: On-Site Denitrification Systems Summary Report

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Introduction 2

Task 1A-1. Establish the target effluent concentration 3

Task 1A-2. Identify the best available technologies for onsite nitrogen removal 3

Task 1A-3. Establish monitoring standards 4

Task 1A-4. Prepare a cost model 4

Task 1A-5. Develop the implementation framework 5

Conclusions 6

Appendices

Appendix A: Horsley Witten Group, Inc. Memorandum Evaluating Level of Nitrogen Removal Needed for Brewster properties

Appendix B: Barnstable County Department of Health and the Environment Advanced Septic System Performance Memorandum

Appendix C: Wright Pierce, Inc. Technical Memorandum on Onsite System Installation and O&M Cost Evaluation

Appendix D: Memorandum from DEP on Monitoring Requirements of Onsite Treatment Systems Used to Treat Nitrogen to Meet TMDL Standards

Appendix E: Horsley Witten Group, Inc. Memorandum on Municipal Implementation of an Onsite Treatment Program.

PLEASANT BAY ALLIANCE
Task 1A: On-Site Denitrification Systems Summary Report

Southeast New England Program (SNEP) Grant - Regional Watershed Permit Implementation Project for Pleasant Bay

Executive Summary

As part of the Southeast New England Program (SNEP) grant issued to the Pleasant Bay Alliance, the Town of Brewster evaluated the potential for using advanced septic systems to reduce the nitrogen discharged into its portion of the Pleasant Bay watershed. The goal was to evaluate the level of nitrogen reduction needed, the availability of technologies that could provide the necessary reduction, and the regulatory structure to be used to implement the program. In addition, the details of system operation, maintenance and monitoring, the level of municipal oversight, and the costs associated with the overall program were evaluated.

The Massachusetts Estuaries Program model used for the Pleasant Bay watershed assumes a nitrogen concentration of 26.25 milligrams per liter (mg/L) for effluent discharged from traditional onsite septic systems. This number is lower than the typical nitrogen concentration for effluent entering a septic system as it takes into account nitrogen removed in the septic system leaching facility as well as in the underlying soil. Using this assumed concentration, it was determined that each septic system in the unattenuated watersheds in Brewster would have to use an advanced nitrogen removal system to meet Brewster's nitrogen reduction goals. Furthermore, these systems would have to meet a treatment level of 12 mg/L to be able to fully meet Brewster's remaining portion of the Total Maximum Daily Load (TMDL) for nitrogen for Pleasant Bay. Currently there are no systems with general approval from the Massachusetts Department of Environmental Protection (DEP) that can provide this level of treatment. There are a couple with pilot or provisional approval that might be able to meet a 12 mg/L threshold.

The key lessons learned from the project for Brewster and other municipalities considering the use of onsite system for nitrogen removal are summarized below:

- Based on discussions with DEP, regular monitoring will be required for all advanced systems including quarterly sampling for the first year, and annual sampling thereafter. Systems that do not have general approval from DEP will have to be sampled quarterly for up to three years.
- Also, according to DEP, each system will need to be inspected briefly on a monthly basis to ensure it is operating as intended.

- The cost for installing and operating an advanced onsite system will depend on the technology that is selected. The project estimated a capital cost for each system of approximately $33,900 and an annual operation and maintenance fee of about $2,360.
- Federal regulations governing the State Revolving Fund (SRF) program allow for loans to privately or publicly owned facilities, and Massachusetts dedicates $5 million a year for septic repair and replacement projects through the State Revolving Fund (SRF). MassDEP is in the process of providing guidance on how to access these loans as part of an overall implementation strategy under a Comprehensive Water Resources Management Plan or Targeted Watershed Management Plan to install nitrogen reducing septic systems. Currently, the SRF program does fund a Community Betterment Septic Program that provides low interest loans to homeowners to upgrade or replace failed septic systems.
- The use of the systems can be mandated through a regulation passed by the Board of Health requiring their use. To increase public input and involvement in the decision, a town could consider adopting a General Bylaw with the details of how the program is implemented included in a subsequent Board of Health Regulation.

Introduction

The Town of Brewster evaluated the option of using on-site denitrification systems to satisfy portions of the Towns' Total Maximum Daily Load (TMDL) compliance responsibilities for Pleasant Bay. This work was conducted under Task 1A of the SNEP Grant issued to the Pleasant Bay Alliance.

The work for Task 1A involved five sub-tasks outlined in the SNEP grant proposal:

1. Establish the potential target effluent concentration for on-site systems;
2. Identify the best available technologies to meet the target concentration;
3. Discuss monitoring standards needed to document onsite system performance;
4. Evaluate the capital and O&M expenses needed to implement a municipal program; and
5. Develop an implementation framework for such a municipal program.

Brewster and Orleans planned to use this information to determine if an onsite septic treatment program is appropriate for meeting a portion of the TMDL for their portions of the Pleasant Bay watershed. As will be discussed further below, the level of treatment needed to comply with the TMDL is such that, at least for Brewster, the costs and implementation challenges may make this approach difficult, if not infeasible, and other options may need to be considered.

Task 1A-1. Establish the target effluent concentration

The Town of Brewster evaluated the number of septic systems that would need to be upgraded with nitrogen treatment systems to remove enough nitrogen to achieve compliance with the TMDL. This information was used as an example to help identify the types of systems that might provide the necessary removal and to evaluate the associated costs, monitoring, and implementation steps needed if an onsite program was established.

In Brewster there are 319 residential properties with onsite septic systems located in the portions of the Pleasant Bay watershed that are not subject to natural attenuation. Considering the nitrogen reductions already achieved at the Captains Golf Course, the Town needs to further reduce nitrogen inputs to the watershed by 982 kilograms of nitrogen per year (kg N/yr). With typical water use of 142 gallons per day (gpd) per home, the average effluent quality from on-site denitrification systems would need to be demonstrate a maximum value of 12 mg/L of nitrogen to achieve the removal goal. This is considerably less than the average effluent quality of 26.25 mg/L concentration of nitrogen attributed to standard onsite systems in the Massachusetts Estuaries Project model for Pleasant Bay. The effluent concentration used in the model assumes the nitrogen enters the septic system at approximately 35 mg/L. Nitrogen is then treated in the leaching facility and in the underlying vadose zone reducing the concentration by 25% to 26.52 mg/L. Further details on this assessment are provided in Appendix A.

Task 1A-2. Identify the best available technologies for onsite nitrogen removal

The April 17, 2020 report by the Barnstable County Department of Health and Environment presents a summary of performance data for thousands of homes using commercially available systems for on-site denitrification. The important conclusions of this report are:

- The average effluent nitrogen concentration for the surveyed systems ranges from 14 to 23 mg/L.
- None of the commercially available systems that have received general use approval from the Massachusetts Department of Environmental Protection (DEP) can reliably reach the 12 mg/L goal
- There are two emerging technologies that show strong promise for meeting the 12 mg/l goal.
- These systems will require up to three years of testing and evaluation before they achieve general use approval.

The report of the Barnstable County Department of Health and Environment is attached as Appendix B.

Task 1A-3. Establish monitoring standards

An initial program to monitor the performance of the onsite treatment systems was developed through conversations with DEP staff. This information was then used to inform the cost model prepared under Task 1A-4. It is assumed that effluent quality monitoring would be in four parts:

- Quarterly effluent sampling of each system for the nitrogen series compounds for the first year to confirm that each system is operating as expected. If the system(s) chosen by a town has not yet achieved general use approval from DEP, the quarterly monitoring may extend up to three years;
- Annual effluent sampling of all systems that have not been subject to quarterly sampling, with approximately 10% of the systems tested each month;
- Additional influent and effluent sampling of each system whose performance does not reach an established threshold (once to confirm non-compliance and to better determine the cause of non-compliance, and a follow-up sample to confirm that the remedial changes were effective).
- Monthly inspection of all systems by a certified operator.

As part of the SNEP project, the Pleasant Bay Alliance work group debated how the performance of the advanced systems would be evaluated and decided that the average effluent concentration of all the I/A systems is most important target to achieve. This average best reflects the amount of nitrogen ultimately entering the Bay and impacting coastal water quality. Some systems may achieve a nitrogen treatment concentration lower than 12 mg/L and others may not reach the target concentrations. Appendix C provides further details on the monitoring needs discussed above and Appendix D summarizes input from DEP on this monitoring program

Task 1A-4. Prepare a cost model

The Wright-Pierce technical memorandum dated July 21, 2020 presents a cost model that predicts capital and O&M costs for a municipal program for on-site denitrification. This model takes into account information from DEP on monitoring requirements and cost information from the Barnstable County Department of Health and Environment.

Using typical values for key cost items, a “base case” estimate was prepared and includes costs as follows for the average system in the program:

- Capital cost $33,900
- O&M cost $ 2,360 per year
- Debt Service $2,540
- Equivalent annual costs $ 4,900 per year

These costs are based on available information for the two systems that might meet the 12 mg/L nitrogen effluent standard needed in the Brewster example discussed above. The capital cost includes the design and construction costs as well as estimates for landscaping needs to rebuild the property after construction. The main cost is for the purchase of the system itself, estimated at $17,500. The O&M costs are based on an average cost over 20 years. It is important to note that during the first year, the O&M costs would be higher because quarterly sampling will be conducted for the year after a system is installed. If a town chooses to use a system that has not achieved general use approval, the additional costs could extend up to 3 years.

The cost model is attached to this Task 1A report as Appendix C.

Task 1A-5. Develop the implementation framework

The implementation of an onsite program would require oversight and management by the Town. Based on discussions with DEP it is clear that a town using such a program would need to be active in ensuring the onsite systems are maintained and monitored and would need to prove that the systems are meeting the performance goals required under the Bay's TMDL.

As part of this Task, Brewster evaluated how such a program would be implemented as discussed in Appendix E. The key issues addressed in the evaluation included:

- The development of a regulatory program to require the use of the advanced onsite treatment systems. The adoption of a general bylaw was recommended, accompanied by a regulation passed by the Board of Health that would provide the details of the design, maintenance and monitoring requirements for systems as they were installed. The two-pronged approach allows for greater public input to the process as the Board of Health can adopt a regulation with minimal public input, while a general bylaw must be approved with a majority vote at town meeting.

- The evaluation of options for managing town oversight of the maintenance and monitoring of individual systems. The Town would need to document each system's performance to confirm compliance with the TMDL and would therefore need to have oversight of the ongoing maintenance and monitoring. This is beyond the level of oversight typically provided for onsite systems which involves the review of the system design and confirmation that it was installed according to the approved plans. The details of such a program would depend on the system(s) selected for use and the specific maintenance requirements associated with them.

- The methods for financing the implementation of the plan. Currently, DEP is in the process of providing guidance on how to access these loans as part of an overall implementation strategy under a Comprehensive Water Resources Management Plan or Targeted Watershed Management Plan to install privately-owned nitrogen reducing septic systems.

Conclusions

The information discussed above provides an overview of what will likely be needed to implement a town-managed advanced onsite septic system program using Brewster's nitrogen reduction goals for its portion of Pleasant Bay watershed as a model. The information shows that onsite systems would need to achieve a very strict nitrogen reduction target of 12 mg/L or less to remove the remaining nitrogen that is Brewster's responsibility under the TMDL. A similar level of nitrogen treatment would likely be needed for subwatershed areas in Orleans as well. There are currently no systems with General Use Approval in Massachusetts that meet this goal. A few systems with pilot or provisional status could achieve this level of nitrogen reduction however, the cost and oversight requirements for using these systems are significant. Each town will have to decide if this is an appropriate approach moving forward. While it may be challenging for a larger area of the watershed, it might be useful in a specific subwatershed or neighborhood.

Appendices

Appendix A: Horsley Witten Group, Inc. Memorandum Evaluating Level of Nitrogen Removal Needed for Brewster properties

Appendix B: Barnstable County Department of Health and the Environment Advanced Septic System Performance Memorandum

Appendix C: Wright Pierce, Inc. Technical Memorandum on Onsite System Installation and O&M Cost Evaluation

Appendix D: Memorandum from DEP on Monitoring Requirements of Onsite Treatment Systems Used to Treat Nitrogen to Meet TMDL Standards

Appendix E: Horsley Witten Group, Inc. Memorandum on Municipal Implementation of an Onsite Treatment Program.

Appendix A - Residential Septic System Treatment Analysis

Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Unit 1 • Sandwich, MA 02563
508-833-6600 • horsleywitten.com

MEMO

TO: Ryan Bennett and Chris Miller

FROM: Mark Nelson, Geraldine Camilli

RE: Evaluation of the Number of Homes in the Pleasant Bay Watershed that will Require an Advanced Septic System to Meet the Nitrogen Reduction Goals for the Watershed.

DATE: December 31, 2018

The Horsley Witten Group, Inc. (HW) has evaluated how many septic systems within the Pleasant Bay watershed will need to be upgraded with an advanced, nitrogen reducing septic system to meet the Town's portion of the nitrogen reduction goal for Pleasant Bay. This was done as part of HW's initial assessment of the implementation steps needed to comply with the nitrogen reduction specified in the Pleasant Bay Watershed permit and as established by the Massachusetts Department of Environmental Protection (MassDEP) in the issuance of the Total Maximum Daily Load (TMDL) for the Bay.

Methodology

Under the watershed permit, Brewster has agreed to remove 2,262 kg/year of nitrogen to meet its TMDL requirements. To date 56 percent of this load reduction has been achieved through reductions in fertilizer use and through the recapture of nitrogen through the irrigation well at the town-owned Captains Golf Course. The Town currently plans on removing the remaining load (979 kg/year) through the advanced onsite program.

Septic system effluent concentration

The load from onsite septic systems within the watershed is based on an assumption in the University of Massachusetts School for Marine Science & Technology (SMAST) model that the nitrogen concentration in septic system effluent that reaches the embayment is 26.25 mg/L. Therefore, the load reduction provided by an advanced onsite system will be based on the difference between 26.25 mg/L and the effluent concentration provided by the advanced system, assuming the water use on the property does not change.

Each advanced onsite technology has its own capacity to reduce nitrogen and the Town is working with the other communities in the Pleasant Bay Watershed to evaluate technologies that may be appropriate for application in Brewster. At the same time, it is worthwhile to

evaluate how many homes may require an upgrade based on the treated effluent concentration that could be provided by an advanced system.

Using the original SMAST model, HW calculated the load reduction that could be provided by advanced systems meeting a series of nitrogen treatment goals. The following four scenarios were evaluated reflecting the expected range of nitrogen treatment that could be expected from advanced systems:

- Scenario 1: Nitrogen rate in the septic system effluent is reduced from the current rate to 19 mg/L.
- Scenario 2: Nitrogen rate in the septic system effluent is reduced from the current rate to 15 mg/L.
- Scenario 3: Nitrogen rate in the septic system effluent is reduced from the current rate to 12 mg/L.
- Scenario 4: Nitrogen rate in the septic system effluent is reduced from the current rate to 10 mg/L.

Parcel Locations

In conducting the evaluation, HW focused on the sub-watersheds to Pleasant Bay with parcels in Brewster where there is little to no attenuation of nitrogen in groundwater before it discharges to Pleasant Bay. This is because some Brewster properties are in areas where there is significant attenuation of nitrogen before it reaches Pleasant Bay. This occurs in areas where nitrogen from septic systems enters groundwater and then flows to a pond and then back into groundwater before it discharges to the Bay. This process removes approximately 50% of the nitrogen contained in the groundwater that enters a pond. In some areas in Brewster groundwater flows through multiple ponds before entering the Bay. It may not be worthwhile to install nitrogen treatment systems in areas where this attenuation is taking place.

As part of the original modeling conducted by SMAST to determine the nitrogen reduction goals for the Bay, the Pleasant Bay Watershed was divided into 18 major sub-watersheds (including one also called “Pleasant Bay”), and 95 smaller sub-watersheds. Eight of the major sub-watersheds, and 34 of the smaller sub-watersheds overlap with the Town of Brewster (i.e., they are located in whole or in part within town boundaries). The Pleasant Bay major sub-watershed is the largest in Brewster, contains the most properties with septic systems and has the least attenuation to account for. Therefore, these preliminary calculations focused solely on this major sub-watershed. In the future, as more details become available regarding advanced systems that might be used in Brewster, an evaluation of the other sub-watersheds can be conducted to determine if it is cost-effective to incorporate them into the program.

Estimate N Loads from Selected Parcels

In order to estimate the number of septic systems in each sub-watershed of interest, HW used GIS information to identify developed residential parcels in Brewster that overlap the sub-watersheds of interest. Some parcels overlap multiple sub-watersheds, so HW conducted the

analysis for parcels that are wholly located within the sub-watersheds of interest, and re-ran the analysis for parcels for which most of the area is located within these sub-watersheds.

The original SMAST model estimated wastewater load by small sub-watershed, rather than by Town, and relied on water use information for individual parcels. In order to evaluate Brewster's load, HW averaged the water use for each sub-watershed across all parcels, and assumed that water use in Brewster is on average the same as water use for all parcels within the sub-watershed. Using the original SMAST model, HW calculated the nitrogen load to Pleasant Bay for the properties described above under the four scenarios, and compared the results to the original model output using the effluent concentration of 26.25 mg/L. For each scenario, HW calculated an average nitrogen load reduction per property for all sub-watersheds. This average reduction was then used to convert a nitrogen reduction for each sub-watershed into a number of properties.

Results

The table below shows the amount of nitrogen removed under the four nitrogen treatment scenarios that were evaluated. There are 319 residential properties either fully within the watershed or with more than 50% of their land area in the watershed. Septic effluent needs to be treated to 10 mg/L (Scenario #4) to fully remove the 979 kg/year needed to meet the TMDL goal. If effluent is treated to 12 mg/L (Scenario #3), the total nitrogen removed is very close the goal (960 kg/year versus 979 kg/year). Under this scenario an additional seven homes in other unattenuated watersheds would require an upgrade to meet the TMDL goal. If commercial or industrial properties are included in the analysis, it is likely the goal will be met under the 12 mg/L treatment scenario and this will be evaluated further in the near future.

This analysis will be updated as further information is available on the treatment capabilities of onsite technologies that may be considered by Brewster, and as SMAST runs new modeling scenarios for the watershed taking into account current and proposed efforts to remove nitrogen from the watershed.

Nitrogen reductions provided by Onsite System Upgrades in the Pleasant Bay Subwatershed

Scenario	Nitrogen Reduction kg/year	TMDL Goal kg/year	Amt Over/Under TMDL Goal kg/year
#1: 19 mg/L	487	979	492
#2: 15 mg/L	752	979	227
#3: 12 mg/L	960	979	19
#4: 10 mg/L	1,096	979	-117

Appendix B - Barnstable County IA Septic Performance Assessment

Assessment of the potential role of alternative onsite septic systems in the nutrient management of the Pleasant Bay Watershed area located in Brewster.

Barnstable County Department of Health and Environment herein assesses the potential use of alternative onsite septic systems (herein referred to as "I/A technology") to meet the TMDL goals for the Town of Brewster portion of the Pleasant Bay Watershed. The premise of this assessment is based on work done for the Town of Brewster by the Horsley Witten Group which stated in their summary of December 2018:

"There are 319 residential properties either fully within the watershed or with more than 50% of their land area in the watershed. Septic effluent needs to be treated to 10 mg/L (Scenario #4) to fully remove the 979 kg/year needed to meet the TMDL goal. If effluent is treated to 12 mg/L (Scenario #3), the total nitrogen removed is very close the goal (960 kg/year versus 979 kg/year)."

An extensive database that is continuously compiled by the Barnstable County Department of Health and Environment and surveils maintenance and performance of residential onsite advanced treatment units from over 20 towns in the Commonwealth of Massachusetts was used in part for this assessment. These data include all systems approved and in use in the Commonwealth. In addition, we report on efforts from Suffolk County, Long Island which is engaged in an aggressive program to replace standard systems to address nutrient loading in Long Island Sound. Finally, data from selected demonstration projects such as Maryland's Bay Restoration, Falmouth Massachusetts West Falmouth Harbor Demonstration Project, LaPine Oregon Demonstration Project, New Jersey Pinelands and smaller grant and demonstration projects were used. Total nitrogen discharge values from single family residences across all projects were averaged for instances where data from at least 20 sites were available from single family residences. In some instances where large datasets were available from different locations and showed significant differences in performance for a particular technology or model, datasets were separated and where possible, manufacturers' different models were analyzed separately. A list of treatment technologies considered is provided below.

Authors' note

Projections of I/A performance expressed herein are based on the data which are dynamic in nature. Performance features of any technology are driven, in part, by regulatory requirements, expectations and market competition. As I/A technologies are increasingly used and performance results publicized, we expect that there will be performance improvements in some cases as product manufacturers modify their products in response to market and regulatory pressures. Accordingly, the assertions regarding performance expressed herein should be considered as of the date of this report and subject to need for regular updates.

The reader is also reminded that in the most regulatory settings where I/A systems are applied, a discharge concentration of 19 mg/L is expected or required. The lack of regulatory pressure and the general increase in cost to achieve levels < 10 mg/L in onsite setting has caused only a few technologies to be developed that can meet the requirements of many TMDLs.

For this analysis, a threshold discharge level of 12 mg/L Total Nitrogen (TN) is used (Scenario #3 -see above and Horsley Witten Group's final report for the Town of Brewster and the Pleasant Bay Alliance) as an indicator that the widespread use of I/A technology could meet the goal of removing 960 kg/year of nitrogen from the Brewster portion of the Pleasant Bay Watershed.

Results

A comprehensive review of field and research data indicate four commercially available technologies and two non-proprietary strategies can meet the above-referenced 12 mg/L total nitrogen removal threshold. The reader should understand that the data reviewed were obtained from systems in the single-residence configuration. As such, to the knowledge of these authors, these systems were not configured with an external carbon source to support denitrification. Some of these technologies can be supplied with an external carbon source and have been shown in cluster systems, serving more than one residence, to be able to achieve better treatment that is not represented in this analysis. Some models of certain products may include carbon additions in their single-family models, however information regarding which models were so equipped was unavailable.

Among the technologies which have smaller datasets (<20 sites), two commercially available technologies bear consideration. The Nitrex™ system employs a pretreatment unit from various treatment technology vendors (to nitrify the ammonia in the wastewater) and a container of cellulosic material (woodchips) configured as an upflow reactor. This system performed well in demonstration projects and data from various sources including the vendor website indicate and average TN of 2.5 mg/L (2.9 – 3.3 mg/L, p=.05). This system has Provisional Approval in the Commonwealth of Massachusetts.

List of onsite innovative advanced (I/A) treatment units investigated.

Amphidrome™
Amphidrome™(Pinelands)
AquaKlear™
Bioclere™ (Pinelands)
Bioclere™ 16 Series
BioMicrobics Biobarrier™
BioMicrobics MicroFAST™ .5
BioMicrobics STARR™
BUSSE GT(membrane bioreactor)
EcoFlo™ Coco Filter (also with denite filter)
Eliminite™
FAST™ 0.9
FugiClean™
HOOT™ (various models)
Hydro-Action™
Layered System Unlined
Layered System Lined
Lined Nitrification area to Woodchip Bioreactor
Nitrex™
Nitroe™
Norweco™ Hydro-Kinetic
Noweco™ TNT
Orenco Advantex™ AX-20
Orenco Advantex™ AX-RT
Pugo™
RUCK
SeptiTech™
SeptiTech™ M400N
SeptTech™ (Pinelands)
SeptTech™ 400
Waterloo Biofilter™

The Nitroe™ (KleanTu, LLC, 300 Old Pond Rd.,STE 206, Bridgeville PA) is a newly developed system with at least 10 installations on Cape Cod and Martha's Vineyard. Monthly samples show an average discharge TN of 10.8 mg/L (8.6 - 13.0 mg/l, p=.05). Nitroe™ is a single tank and can be retrofitted into an existing septic system that contains a septic tank and a Soil Treatment Area (STA). It can be configured for passive flow if the elevation difference between the existing septic tank and the soil treatment area inlet exceeds 3

inches and components are horizontally proximate (John Smith, Corporate Environmental Solutions, personal communication). The Nitroe™ has provisional approval in Massachusetts.

Two additional commercially available technologies, the data from which is emerging from extensive testing in Long Island as part of the "Reclaim Our Water" initiative, also show promise to meet the 12 mg/L treatment level maximum. Hyro-Action™ (https://www.hydro-action.com/) developed by an Indiana-based company was reported to produce an average TN in the discharge of 10.6 mg/L over 76 samples taken from 20 systems. FugiClean™(https://www.fujicleanusa.com/) similarly showed comparable treatment in this same demonstration project (11.4 mg/L TN in the discharge of 83 samples taken from 20 systems). These averages have changed slightly but not significantly since the October 2019 (2018 Annual Report) of that project. These two technologies remain the best performing of the field of the commercially available single-family home technologies advancing through the Suffolk County New York permitting process as of March 2020.

Finally, three experimental configurations of non-proprietary nitrogen removal systems bear mention since they have been the subject of study at the Massachusetts Alternative Septic System Test Center and have been advanced in Long Island Suffolk County, New York through the Clean Water Center of Stony Brook University. As of February 2020, these systems remain in the "experimental" stage in Long Island and in the Site-specific Pilot Approval stage in the Commonwealth of Massachusetts. The three configurations are discussed separately below.

Simple Layered Systems

The simple layered system involves layering a mixture of 50% sand and 50% sawdust (by volume) beneath a nitrifying layer of sand situated directly beneath the septic-tank dispersal system unit in a soil treatment area. In Massachusetts ten such systems have been installed, with only four installed at year-round residences and only two of these have sufficient data on which to base conclusions. Collectively, data suggest that although removal rates exceed 85% in warmer months, performance decreased significantly below this value when septic tank effluent temperatures are less than 10^{o} C (generally January – April in any year). Generally, however even at these colder temperatures the TN removal is greater than 50% of the influent TN. The diminished cold-temperature performance was also noted in one of the two systems installed in Long Island receiving septic tank effluent within the TN concentration range expected for normal households (>60 mg/L). The other of the two systems in that project exhibited little if any diminishment of treatment during periods of low temperature. A third system in Long Island received unusually low influent nitrogen (less than 20 mg/L) and was not considered in this analysis as a valid example. Simple layered systems in the Massachusetts Alternative Septic System Test Center (MASSTC) venue perform similarly to field installations, exhibiting decreased performance at temperatures below 10^{o} C (generally January – April). We conclude that this technology will not support the need for TN levels < 10 mg/L on a consistent basis. We note, however, that in the test center venue where hydraulic loading rates are measured with precision, two simple layered systems exhibited TN levels averaging < 10 mg/L over the year particularly when a hydraulic loading rate of 0.6 gal/sq. ft./day were applied every day.

Lined layered Systems

Lined layered systems are characterized by having an impervious liner beneath both the nitrification layer (18" of sand alone) and denitrification (18" of a sand mixed with sawdust). The collected percolate

is collected and directed toward an area for final disposal. This is opposed to simply allowing the percolate to move downward into a native soil horizon as above. The advantage of this type of system is that the sand/sawdust denitrification layer is maintained in a saturated condition, ensuring longer useful lifespan of the cellulosic material by preventing its aerobic decomposition. Two such systems in operation at MASSTC exhibited discharge concentrations of 7.2 and 7.1 mg/L over three and four years of operation, despite some diminished performance in winter months. Two of the three installations at residences in Long Island showed similar performance following in one instance a three month start up. The remaining system was installed in late autumn- early winter and hence no warm weather data are available.

The disadvantage to this configuration is the need for a final disposal area. Based on the greater performance stability of this configuration during colder periods, we conclude that this system could however meet the requirement for an overall average TN level of 10 mg/L. In addition, questions regarding the longevity of the cellulosic media are addressed in part by maintaining saturation in the media. There is general agreement that maintaining saturation will prevent the carbon exhaustion for decades.

"Box" Type Wood-Based Systems

This non-proprietary configuration involves a lined nitrification bed of 18" of sand with the collected percolate directed to a box of woodchips that is piped for upflow passage of the percolate prior to discharge. The system is much like the commercially available Nitrex™ but uses a slow rate sand bed sized as to receive septic tank effluent and act as a nitrifying reactor. A system installed at MASSTC and operated for three years has an average TN discharge concentration of 6.0 mg/L (excluding three dates in April 2018 when rainwater was inadvertently entering the pump chamber). A single installation in Long Island and operated for seven months exhibited a final TN concentration of 3.2 mg/L.

Similar to the lined layered system described above, this system requires an addition area for disposal. We believe, however that this system could consistently achieve TN discharge < 10 mg/L very similar to its commercial analogue, the Nitrex™ system. In addition, replacement of the woodchip carbon source upon its exhaustion would be simplified by the ready access.

The Path Forward

The information above suggest at least three paths forward for Brewster to satisfy its obligation for nutrient limitation in the Pleasant Bay Watershed using advanced onsite septic system treatment units (Innovative/Alternative Systems - I/A).

Path 1 - Pursue the installation of the four technology types and non-proprietary methods indicated at the 319 residences in the watershed.

Four commercially available technologies have a high or moderately high probability of meeting the discharge limit of < 12 mg/L TN. Two of these technologies involve lignocellulosic (wood based) denitrification systems. The Nitrex™ system has limited single-family installations in the Commonwealth. Nevertheless, data from the LaPine Demonstration Project, earlier testing of the commercial unit at the Massachusetts Alternative Septic System Test Center(MASSTC), two installations on Cape Cod and extensive experimentation of a generic version at MASSTC suggest that this system type is a viable

alternative which can achieve average TN levels in the discharge of < 10 mg/L. In its generic form, an estimated costs for this system is $22,000 based on an assumption that a small leaching system can be installed following the discharge from the woodchip reactor. A quote from the vendor of the Nitrex System™(the proprietary version) indicates a $30,000 cost, which might benefit by a price reduction due to an economy of scale (Pio Lombardo, Lombardo Associates, Inc., personal communication January 6, 2020). The Nitrex™ has a Provisional Approval in the Commonwealth while the generic version would require a review from Massachusetts DEP and possibly require a progression through an extended approval process.

Another candidate system is a new development from a newly formed company – KleanTu™. The unit name is NitROE™. It has been the subject of a Clean Energy Center Grant and has 11 installed systems. KleanTu™ is presently seeking Provisional Use Approval in the Commonwealth based on favorable results from the Pilot Approval systems. The equipment and engineering support cost of this unit is $12,250. With the additional cost of a soil treatment area and attendant engineering costs, a conservative total cost estimate in situations where a new system is being installed approximates $22,000. This unit can be retrofitted onto an existing septic system provided that the elevation between the septic tank and distribution box exceeds ~3 - 4 inches. The retrofit would reduce overall costs and reuse existing infrastructure.

Two additional commercially available candidate technologies are emerging based on the extensive sampling program and reporting of results from the "Reclaim Our Water" Program in Suffolk County New York. The FugiClean™ and Hydro-Action™ are mechanical units that occupy the top two performance rankings in that program and demonstrate the ability, on average, to approximate the 12 mg/L limit on TN Discharge concentration. FugiClean™ presently has a Provisional Use Approval in the Commonwealth of Massachusetts and could be used in part (and in accordance with the 50-system limit imposed under that approval) to meet the loading limitations in the watershed. The Hydro-Action™ system could be installed in a similar manner in the watershed if the company met the requirements for a similar approval. Costs of system installation for these two technologies is difficult to estimate but in Suffolk County New York, the costs for installing a FugiClean™ system ranged from $13,900 – $19,800 in situations where an existing soil treatment area (aka "leach field") could be used. Under this same scenario the costs of installing a Hydro-Action™ unit was $14,700 - $19,670. In both instances, the costs of design and engineering is not included.

Path 2 – Review selected assumptions of the TMDL modelling for appropriate assignment of credits for higher performing I/A systems as well as reviewing the required discharge concentration that is required for I/A to still meet the TMDL.

Under this path we would request that the MEP team consider a re-evaluation of selected model assumptions that fail to appropriately "credit" the removal capability of advanced treatment units that have discharge concentrations <10 mg/L. A chief deterrent of further development, advancement and deployment of onsite septic system treatment is due to the lower "credit" and the resulting propagation to a higher cost/per/pound estimate for nitrogen removal. Certain assumptions are questioned such as concentration of septic tank effluent applied to the soil treatment area (which we and the literature support as being 60-65 mg/L TN), attenuated concentration reaching the ground water beneath the system (which is assumed to be 26 ± mg/L), and TN removal in the vadose zone subsequent to I/A application. These authors believe that the demonstrated removal rates possible in selected

technologies, where actual load reductions calculated contrast with those levels assigned in computer model runs and assumptions, do compel a review of these assumptions for the purpose of proper assignment of advanced I/A credits.

This re-evaluation may also open up opportunities for using other I/A treatment technologies that approach 14 – 18 mg/L TN discharge concentration and others yet to be identified. In short, the range of options for the Brewster portion of the Pleasant Bay Watershed may expand and offer economic advantages for I/A use following any revisions of the model.

This path should also include discussions with permitting authorities regarding treatment technologies not yet approved in the Commonwealth and their allowance for installations in context of the watershed permit. Many of the treatment units showing better performance (i.e. Hydro-Action™) in Long Island presently have limited or no approvals in the Commonwealth. Their pursuit of the Massachusetts market is overshadowed by the large market incentive in Long Island and the perceived difficulty and length of the Massachusetts approval process. An expedited review process of data from other active and credible demonstration efforts might be warranted and an adjusted permitting process might be considered based on performance data collected from highly credible sources.

Path 3 – Estimate nitrogen trading possibilities with adjacent watershed towns and determine whether, in combination with these trades, a higher onsite septic system effluent TN concentration could still meet the TMDL.

This path is a blending of two strategies. If some nitrogen reductions are assumed by a trading partner, this could adjust the necessary nitrogen reductions (and hence the required nitrogen concentration in the effluent) for each lot. Higher allowed nitrogen reductions from each I/A system translates to a higher probability of treatment level compliance and possible cost savings.

Again, the use of adaptive management could also be applied here. Any broadscale use of I/A technologies will be monitored for compliance. Should the monitoring reveal higher than expected treatment levels the scaling of nitrogen trading as well as the required number of I/A systems can be adjusted.

Appendix C - Wright-Pierce IA Cost Memo

WRIGHT-PIERCE
Engineering a Better Environment

MEMORANDUM

TO:	Carole Ridley---PBA	DATE:	21 July 2020
FROM:	Mike Giggey	PROJECT NO.:	13351D
SUBJECT:	Pleasant Bay Watershed Permit Implementation Elements and Costs for an On-Site Denitrification Program		

Wright-Pierce's scope of work for Task 1A of the SNEP project (Subtask 4) includes the development of a cost model to predict the capital and O&M costs for municipal on-site denitrification programs. The intention is to develop cost data that will help one or more towns refine their TMDL compliance plans. This information will also provide a basis for comparison of this technology with other nitrogen control approaches, to serve as input into our recommendations related to nutrient trading.

This memo first discusses the appropriate approach to TMDL compliance using on-site systems, based on recent discussions with DEP staff. It then lays out the likely components of a municipal program. Cost estimates are then presented for those components.

SUMMARY

To be approved by DEP, and to gain credit for TMDL compliance, the use of individual on-site denitrification systems must be within a town-managed program, with the town acting as the responsible management entity.

Principal cost elements of a municipally-managed program include:

Initial costs	Recurring costs
Program implementation	Routine inspection, maintenance. and testing
Surveys, permits and easements	Electricity
Equipment purchase and installation	Septage pumping
Site restoration	Non-compliance inspection and testing

For the assumptions presented in this memo, the costs are predicted to be:

Capital cost	$33,900
O&M costs	$ 2,360 per year
Debt service	$ 2,540 per year
Equivalent annual cost	$ 4,900 per year

FUNDAMENTAL APPROACH TO TMDL COMPLIANCE

A town should select one or more nitrogen control approaches (e.g., sewers, PRBs and shellfish aquaculture) and then set target nitrogen removal goals for each approach. For the purposes of this analysis, I have assumed that a town has identified 300 homes where individual on-site

denitrification systems would be installed. The nitrogen removal goal would be established utilizing water consumption data for the homes, assumptions on consumptive use, and a target effluent concentration that is sufficiently below the 26.25-mg/l MEP-assumed groundwater impact of conventional septic tank and leachfield systems.

Historically, on-site denitrification systems have been required by town boards to address nitrate loading concerns or to protect nearby sensitive receptors. These systems are typically purchased and installed by the homeowner, who also is responsible for system monitoring and repair. Typical town involvement is to require the installation of such systems, arrange for performance data to be entered into the County database, and then nominally follow up on systems that fall into disrepair, or fail to perform according to standards.

In a municipal program aimed at TMDL compliance, a significantly more robust approach is needed. In this setting, the town's involvement might include:

- owning and operating the denitrification systems, or
- overseeing privately-owned and operated systems, or
- overseeing privately-owned systems with municipal O&M and sampling.

It is DEP's stated position that the use of on-site denitrification for TMDL compliance will require municipal oversight. Accordingly, this memo assumes that the town must be the managing entity, not the individual homeowner.

Historically, in order for on-site denitrification systems to be eligible for DEP SRF financing, the systems must be municipally owned and must be maintained by the town or by the town's contract operator. While SRF financing is attractive, municipal ownership of wastewater treatment equipment located on private property imposes legal and logistical hurdles. For the purposes of this analysis, it is assumed that the town would forego SRF financing in order to avoid those hurdles. Each town must weigh the advantages and disadvantages and make the decision that is appropriate to its circumstances. (Recently, DEP has begun discussion that may allow SRF funding for privately-owned systems. Further, the Community Betterment Septic Program, a part of the SRF program, could be amended to fund I/A systems, even if the Title 5 system has not failed.)

COST ELEMENTS

A municipal program for nitrogen reduction using on-site denitrification systems would entail both capital costs and operation and maintenance costs. This analysis considers all of those costs whether those expenses are incurred by the municipality or by the property owner.

Capital Costs

The initial administrative costs to put in place a DEP-approved management program would include:

- Setting up the program, including drafting and passage of enabling regulations
- Determining which properties would participate
- Establishing the target effluent concentration
- Obtaining blanket easements for system access and testing (not site-specific)
- Undertaking an equipment selection process to achieve the lowest reasonable cost with associated material and equipment specifications and performance assurances (the town would identify the one or two best systems that would then be purchased by the homeowners)
- Setting up a financial assistance program
- Selecting a contract operator to provide inspection, sampling and repair of all systems (the operator would be selected by the town and paid for by the homeowner)
- Orchestrating a remote monitoring system for early detection of equipment failures
- Gaining DEP approval of the program

Costs at each property would include:

- Completing site-specific survey and design activities
- Obtaining necessary permits
- Obtaining site-specific easements, if necessary
- Purchasing and installing the necessary equipment on each property
- Performing site restoration to accommodate the new equipment within existing backyard features such as decks, pools and landscaping
- Installing influent pumps at most homes
- Installing new leaching fields at some properties
- Upgrading of the electrical system at some homes
- Preparing as-built drawings
- Installing standby generators at some homes (homeowner decision)

The failure of a treatment system to achieve the target effluent nitrogen concentration is termed a "non-compliance event" for the purposes of this analysis. Instances of non-compliance may often involve failure of key equipment items such as pumps or blowers. Instrumentation could be included in the equipment package to sense basic system "trouble" conditions, with an alarm to notify the property owner, or (with telemetry or cellular system) to notify the town at a central location. In the latter case, there would be costs to install a telemetry/cellular alarm system at a central location.

O&M Costs

"Operations and Maintenance", as used herein, includes inspection, maintenance, sampling, laboratory analysis and equipment replacement, as well as associated oversight and management functions.

Recurring costs at the individual properties would include:

- Electricity
- Septage pumping
- Routine inspections
- Routine effluent monitoring
- Non-compliance inspections
- Non-compliance influent and effluent monitoring
- Chemicals (alkalinity adjustment may be needed for certain remedial actions)
- Repairs
- Periodic replacement of mechanical, electrical or instrumentation components.

Recurring costs borne directly by the municipality would include

- Compiling water use data for each property
- Overseeing contract operators
- Enforcing warranty provisions on system suppliers
- Reporting annually on the overall nitrogen removal achieved
- Maintenance of the central alarm system if used
- Ensuring compliance with DEP procedures for approval of I/A systems (could be as long as 3 years for new technologies that must gain General Use Approval)
- Overall management of the program

It is assumed that influent and effluent quality monitoring would be in three parts:

- Quarterly effluent sampling of each system for the first three years (or for as little as one year for systems that have General Use Approval)
- Annual effluent sampling of all systems that have not been subject to quarterly sampling (10% of all systems sampled each month)
- Additional influent and effluent sampling of each system whose performance does not reach an established threshold (once to confirm non-compliance and to better determine the cause of non-compliance, and a second sampling to confirm that the remedial changes were effective).

The current design life of an on-site denitrifying system is yet undefined in this municipally-managed approach. The design of typical off-the-shelf equipment and tankage may reflect market pressures to maintain costs at a low level and such systems would be expected to have a shorter

life than traditional public infrastructure. If a municipally-specified system is installed, then better-than-average quality might be expected, albeit at higher-than-market costs. Conversely, if low-first-cost equipment and tankage are installed, then it would be prudent to assume a shorter effective life, perhaps 15 years (compared to the traditional 20-year life). The frequency and intensiveness of periodic repairs must also be considered.

As part of the SNEP project, the Pleasant Bay work group has debated the target nitrogen concentration to be achieved and decided that the target is the average effluent concentration of all the I/A systems that is most important. The monitoring program should be flexible enough to identify those systems that are performing poorly so that action can be taken to improve their performance and reduce the average effluent concentration toward the target. It seems that the lower the effluent nitrogen target, the more systems will require added attention. Traditional use of on-site denitrification systems has been to install them and then "walk away and hope for the best". For TMDL compliance under a watershed permit, a hands-on proactive program is warranted.

A three-year start-up period is suggested in this analysis to accomplish three goals:

- Allowing time for new technologies to gain DEP General Use Approval;
- Addressing warranty problems with equipment and tankage; and
- Establishing a performance database to allow a cost-effective statistical approach to long-term monitoring.

If the selected technology already has General Use Approval, a shorter start-up period would be possible, perhaps as short as one year. The number of samples to be analyzed in a 300-unit program would be as follows, assuming that 30% of systems would require non-compliance actions:

Initial period of 1 year

Year 1	180 influent samples	1,380 effluent samples
Years 2 to 20	180 influent samples/yr	540 effluent samples/yr
Average year	180 influent samples/yr	582 effluent samples/yr

Initial period of 3 years

Year 1 to 3	540 influent samples	4,140 effluent samples
Years 4 to 20	180 influent samples/yr	540 effluent samples/yr
Average year	180 influent samples/yr	666 effluent samples/yr

Over the 20-year life of the project, the added initial sampling for yet-unapproved technology would add about 20% to the number of influent and effluent monitoring.

COST ESTIMATES

I set up a detailed spreadsheet to allow the calculation of costs for a program overseen by a town intending to reduce watershed nitrogen load and gain credit under the Watershed Permit, using I/A systems installed at individual homes or business. I have incorporated significant flexibility into this model to accommodate future decisions on the details of the specific municipal system and DEP's stance with respect to demonstration of actual removal. All costs are expressed in current (early 2020) dollars.

Results

Using typical values for key cost items, a "base case" estimate was prepared and is summarized in Table 1. The base case includes costs as follows for the average system in the program:

Capital cost	$33,900
O&M cost	$ 2,360 per year
Equivalent annual costs	$ 4,900 per year

These O&M costs are the average over 20 years. It is important to note that during the first three years (for new systems without General Use Approval), the O&M costs would be higher ($2,840 per year) due to more frequent inspections and effluent monitoring. (These costs would apply for only one year for systems with General Use Approval.)

Assumptions Related to Capital Costs

1. Blanket easements would be granted to cover public access to most systems. Site-specific easements ($4,000) would be needed in some cases, assumed to be 10% of all lots.
2. All lots would have new treatments systems installed at $17,500 and 80% of the systems would require influent pumping at $3,500.
3. New $10,000 leaching fields would be needed at 20% of the homes; the remainder would have Title-5-compliant systems with at least 15 years remaining life and would not be replaced at the time of installation of the I/A system.
4. Basic site restoration would cost $2,000 per home, and 15% of the homes would have special sitework needs at $6,000 per home.
5. It would be a homeowner decision on whether to install a standby generator, and 15% of the homes would do so at $5,000.
6. Some homeowners would require a $3,000 upgrading of the home's electrical system.
7. The town's overall DEP-approved management program would cost $180,000 to set up and those costs would be shared equally by all properties at $600 per lot.

Assumptions Related to O&M Costs

1. A one-hour inspection of all systems would be conducted each month throughout the program.
2. During the first three years of the program (or just the first year for systems with General Use Approval), quarterly effluent sampling would occur at all systems, with laboratory tests including BOD, TSS, nitrogen species, pH and alkalinity. After the initial period, systems would be sampled annually (10% sampled each month) and tested for nitrogen species only.
3. About 30% of all systems would require resampling due to failure to meet the established threshold effluent nitrogen concentration. Those system would be visited by the contract operator to determine the cause of the non-compliance, and there would be influent and effluent sampling of BOD, TSS, nitrogen species, pH and alkalinity. While some systems might experience more than one episode of non-compliance, those have not been considered.
4. Treatment system repairs would cost $500 every 5 years.
5. The town would have routine responsibilities of oversight and reporting that would cost $66,000 per year and spread equally to all properties at $220 per year,

Assumptions Related to System Replacement

It is assumed that not all of the new I/A systems will last for 20 years. About 10% percent of all systems will require replacement (at 70% of original equipment cost) in 15 years. The present worth of those future costs is about $6,800 for those systems that do not last 20 years.

SENSITIVITY ANALYSIS

Given the uncertainty associated with certain assumptions, it is appropriate to see how varying assumptions change the overall average cost. Looking at annualized costs (O&M costs plus debt service), the most important cost components are:

Capital cost of treatment system and pump	30% of total annualized coats
Routine maintenance, inspections and testing	27%
Design, permitting, easements and as-builts	11%
Electricity	7%
Program costs	5%
Non-compliance inspection and testing	4%

About 85% of the overall cost is associated with these 6 cost categories. Note that non-compliance inspection and testing comprise only 4% of the total annualized costs.

The base case has an equivalent annual cost of $4,900. Changes in some of the assumptions yields other estimates:

Cost increases		
1. 10% higher equipment costs	$5,050 per yr	($150 more than base)
2. 15% more frequent monitoring	$5,100	($200 more)
3. Fewer homes covering program costs (150)	$5,160	($260 more)
4. Items 1, 2, and 3 combined	$5,510	($610 more)
Cost reductions		
5. 10% lower equipment costs	$4,750 per yr	($150 less than base)
6. 30% lower site restoration costs	$4,800	($100 less)
7. 20% less routine monitoring	$4,630	($270 less)
8. 40% less non-compliance monitoring	$4,810	($ 90 less)
9. Municipal financing (2%, 20-yr)	$4,470	($430 less)
10. Items 5, 6 and 7 combined	$4,380	($520 less)
11. Items 7, 8 and 9 combined	$4,110	($790 less)

The various scenarios identified above show a cost range of $4,100 per year (16% less than the base case) to $5,500 per year (12% higher than the base case). The cost model is configured to rapidly estimate costs for other potential changes in the key assumptions.

The base case assumes a 3-year start-up period, in part to accommodate new technologies that have not gained DEP General Use Approval. If approved technologies were used, and the start-up period could be reduced to 1 year, then there would be about 20% less routine monitoring costs and the overall equivalent annual cost would be close to the $4,630 figure shown above for Item 7.

This memo reports “all-in” costs, regardless of the party who pays those costs. Various cost recovery scenarios are possible, just as they are for any technology. If the town were to make a $18,100 grant to each participating homeowner (to cover equipment costs and initial program costs), the remaining annualized cost for each homeowner would be about $3,600, or $1,300 less than the base case. If the town were to cover the debt service on the grants and the on-going program costs with property taxation, the tax levy would increase by $400,000 per year for this 300-home scenario (a small fraction of which would be paid by the 300 homeowners).

The cost analysis reported here is consistent with the approach that towns take in their comprehensive wastewater management plans (CWMPs). “All-in” costs are reported, then refined by considering how those costs will be allocated (to users, put on the overall tax base, etc.) The readers of this memo should be careful to compare the “all-in” costs reported here with the “all-in” costs typically reported in CWMPs for other technologies. A second comparison could include

the costs after grant and loans, reflecting all available funding sources. Traditionally, funding entities expect the applicant to demonstrate that the selected program has the lowest cost of available options, based on the total costs, before grants and loans.

Table 1
Costs for a Municipal On-Site Denitrification Program

	Costs for One Home	Percent Applicable	Avg Cost for All Homes
Capital Costs			
Survey and design	5,000	100	5,000
Permitting	1,000	100	1,000
Site-specific easements	4,000	10	400
Purchase/install I/A	17,500	100	17,500
Purchase/install infl. pump	3,500	80	2,800
Upgrade leaching field	10,000	20	2,000
Site restoration--routine	2,000	85	1,700
Site restoration--special	6,000	15	900
Emergency generator	5,000	15	750
Upgrade electrical service	2,500	10	250
As-built drawings	1,000	100	1,000
Program costs	600	100	600
Total			33,900
O&M Costs			
Electricity	360	100	360
Septage pumping	450	25	113
Routine inspections	1,080	100	1,080
Routine laboratory analysis	261	100	261
Non-compliance inspections	360	30	108
Non-compliance lab analysis	370	30	111
Chemicals	50	10	5
Repairs	500	20	100
Program costs	220	100	220
Total	6,802		2,358
Replacement Costs			
Present worth of equipment	6,802	10	680
Summary			
Capital Cost			33,900
Present Worth of Replacement			680
Total			34,580
Debt Service 4%, 20 yr	CRF= 0.07358		2,544
O&M Cost			2,358
Equivalent Annual Cost			4,902

All cost expressed in early 2020 dollars 21-Feb-20

Appendix D - MA DEP Memo

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Kathleen A. Theoharides
Secretary

Martin Suuberg
Commissioner

Appendix D
Sampling and Monitoring Requirements for I/A Systems

Introduction

The proper management of on-site denitrifying systems is essential in insuring that a community can meet its nitrogen reduction goals if it intends to use these technologies in pursuit of Total Maximum Daily Load (TMDL) requirements. This includes operation and maintenance and sampling and monitoring. This document provides a protocol for the management and monitoring of on-site denitrifying systems that has been reviewed and accepted by the Massachusetts Department of Environmental Protection.

The use of Innovative/Alternative (I/A) systems as part of a comprehensive nitrogen management plan requires municipal oversight. MassDEP has long held the position that given that critical importance of insuring proper operation under these circumstances, I/A operation and management cannot be left to the individual homeowner. In that regard, communities will need to maintain a management program staffed by appropriately certified wastewater treatment plant operators. Communities have the option of using municipal staff or contract operators overseen by the municipal government.

It is important to note that this protocol differs from the sampling and monitoring requirements for I/A systems regulated under Title 5 of the State Environmental Code (310 CMR 15.000). Any measures implemented to meet TMDL compliance on a watershed wide basis require strict oversight and comprehensive management. I/A systems are no different, and the operations, monitoring and management protocols described herein are necessary to assure that these systems are meeting the performance standards required to achieve the ultimate goal of habitat restoration.

Sampling and Monitoring Protocol

This protocol seeks to strike an appropriate balance between compliance monitoring and cost. Considering that communities will likely require several hundred system installations, it is not practical to sample each system every month. Accordingly, the protocol strives to attain a statistically significant monthly sampling schedule where 10% of the systems are randomly sampled each month, ensuring, however, that every system is sampled at least once per calendar year. In addition, each system will be inspected monthly to insure that it is operating properly.

This information is available in alternate format. Contact Michelle Waters-Ekanem, Director of Diversity/Civil Rights at 617-292-5751.
TTY# MassRelay Service 1-800-439-2370
MassDEP Website: www.mass.gov/dep

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The sampling, monitoring and management protocol will follow these steps:

1. a. For the first year of operation, all systems shall be sampled and tested quarterly for 5-Day Biochemical Oxygen Demand (BOD_5), Total Suspended Solids (TSS) and Total Nitrogen (the sum of Total Kjeldahl Nitrogen, Nitrite-Nitrogen and Nitrate-Nitrogen) to insure proper installation and operation.

b. After the first year of installation systems for sampling and testing shall be selected randomly and sampled as follows:

i. For systems with General Use Approval, 10% of the total number of systems installed shall be sampled and tested for 5-Day Biochemical Oxygen Demand (BOD_5), Total Suspended Solids (TSS) and Total Nitrogen (the sum of Total Kjeldahl Nitrogen, Nitrite-Nitrogen and Nitrate-Nitrogen) every month.

ii. For systems with Provisional Use Approval, quarterly testing shall be required in accordance with the system's Provisional Use Approval certification.

Random system selection will be done such that any system previously tested shall be removed from the sampling population until all systems have been tested after which the entire population shall once again be pooled for random selection.

2. Every system shall be inspected a minimum of once a month to insure that all mechanical components are operational.

After the first two (2) years of inspections the municipality may submit a request to meet this requirement through remote monitoring. MassDEP will consider the request depending upon how robust and reliable the remote monitors are.

<u>Noncompliance</u>

For any system that fails to meet required effluent limits, resampling will be required within thirty (30) days and monthly thereafter until two consecutive samples meet effluent limits. During this period of increased sampling, the operator shall evaluate the performance of the system and provide MassDEP with a report describing the findings of that evaluation including, but not necessarily limited to, the cause of effluent violations, corrective measures taken and operational considerations to prevent future violations.

Appendix E - Implementation Memo

Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Unit 1 • Sandwich, MA 02563
508-833-6600 • horsleywitten.com

MEMORANDUM

To: Chris Miller, Natural Resource Director
Ryan Bennett, Town Planner

From: Mark Nelson, Jane Estey

Date: December 31, 2018, Revised March 30, 2020

Re: Implementation of an Onsite Septic System Treatment Program for the Pleasant Bay Watershed

---

The Horsley Witten Group, Inc. (HW) has evaluated Brewster's requirements and options for the implementation of a program to install, operate and monitor advanced onsite septic systems for nitrogen removal within the Pleasant Bay watershed. The goal of this program is to remove the remaining nitrogen from sources within the watershed to meet the Total Maximum Daily Load for Brewster's portion of the Pleasant Bay Watershed.

This report has been prepared to identify the issues involved in establishing the program and to provide some initial recommendations on how to move forward. It is anticipated that the implementation process will be refined over the next one to three years with significant input from the Select Board, the Board of Health and town residents. Funding for this project was provided by the Department of Housing and Community Development's District Local Technical Assistance program through the Cape Cod Commission. This funding was applied as a match to the Southeast New England Program grant issued to the Pleasant Bay Alliance. The initial work on this memo was completed in December 2018 and has been updated now to reflect more recent evaluations and discussions as the work in Task 1A of the SNEP grant, of which this has been a part, has been completed.

Background

Pleasant Bay is impacted by excessive nitrogen coming from sources within its watershed; that area which contributes groundwater to the Bay. Septic system discharges are the largest source of nitrogen in the watershed, followed by fertilizers, road runoff and agricultural sources. Approximately 25 percent of the Pleasant Bay watershed is located within Brewster, with the remaining watershed areas in Orleans, Harwich and Chatham (Pleasant Bay Alliance, May 2018).

The Massachusetts Department of Environmental Protection (MassDEP) has established a TMDL for the Bay (Mass DEP, May 2007) based on a model developed by the University of Massachusetts School for Marine Science & Technology (SMAST, May, 2006). Based on this information, Brewster has partnered with the other towns within the watershed to develop a Targeted Watershed Management Plan to restore Pleasant Bay. The plan is the foundation for the watershed permit between the four Pleasant Bay towns and the MassDEP issued in August, 2018 to manage the towns' actions to achieve TMDL compliance for Pleasant Bay over the next 20 years. The permit identifies the steps each town will take to meet the TMDL over the next 20

years and allows them to utilize non-traditional options for nitrogen removal, like the onsite systems proposed for Brewster.

Under the watershed permit, Brewster has agreed to remove 2,262 kg/year of nitrogen to meet its TMDL requirements. To date 56 percent of this load reduction has been achieved through reductions in fertilizer use and through the recapture of nitrogen through the irrigation well at the town-owned Captains Golf Course. The Town is evaluating the possibility of removing the remaining load through an advanced onsite program.

Implementation Goals

The goal of Brewster's advanced onsite treatment program is to upgrade enough onsite systems within the watershed to remove the remaining nitrogen needed to meet Brewster's TMDL requirement for Pleasant Bay. Approximately 980 kilograms of nitrogen need to be removed through the onsite program under current conditions. Additional nitrogen removal may be needed to accommodate future development within the watershed.

The planning for a successful advanced onsite system program requires consideration of several issues to ensure it is successful and will be in compliance with the TMDL and the watershed permit. They include:

- Development of a regulatory program to implement the advanced onsite system program;
- Selection of the appropriate nitrogen removal requirements for the proposed onsite systems to ensure the TMDL goal is met;
- Selection of the appropriate advanced onsite systems to incorporate in the program, or the selection of performance standards for the systems to be used, to allow for the inclusion of new technologies over time;
- Determining the number and location of properties where the use of an advanced system will be required;
- Development of an operation and maintenance program with clear oversight by the Town to ensure the systems that are installed and operated properly to meet their nitrogen reduction requirements; and
- Development of monitoring programs under the Town's supervision to confirm that the advanced systems are in compliance with the state's septic system regulations (Title 5, 310 CMR 15.00) and DEP's monitoring requirements to confirm TMDL compliance.

HW has conducted an initial analysis of these issues as discussed below

Regulatory Approach

A regulation requiring the use of advanced onsite systems in the Pleasant Bay watershed will be needed to implement the program. There are two regulatory mechanisms that could be used: the adoption of a general bylaw or the adoption of a Board of Health regulation. HW recommends a combination of both. A general bylaw will require the use of the advanced onsite systems in the watershed with the appropriate number and treatment capability to meet Brewster's portion of the TMDL. The general bylaw will also mandate that the Board of Health

develop regulations that provide the details of how the program will be implemented and administered over time with authority for enforcement with the Board of Health.

A general bylaw must be adopted by a simple majority at Town Meeting. Using this approach, the Town is given the opportunity to review and approve the proposed program and make an affirmative vote to adopt it. Board of Health regulations are adopted by a simple majority of the Board. This process doesn't provide for the same level of involvement for Town residents. However, having the Board adopt the implementation regulations allows opportunities to change or update the requirements over time, without the need to return for a Town Meeting vote. This will be helpful if new technologies are identified, or if there are other changes that warrant updates to the regulations.

This hybrid approach provides the benefits of both approaches; input from all Town residents in the approval of the bylaw, and flexibility to implement the program and adapt to changing circumstances through the proposed Board of Health regulations. The general bylaw could incorporate provisions for how the program will be financed, if the Town agrees to fund a portion of the costs (see the Financing section below).

A draft General Bylaw is attached to this memo in preliminary form. Additional detail will need to be added as the decisions on how the program will be implemented are made.

Advanced System Selection and Treatment Requirements

Information on the advanced systems that Brewster might consider for use is currently being developed by the Pleasant Bay Alliance through the Southeast New England Program (SNEP) grant it received to help implement the Pleasant Bay watershed permit. This analysis will review the available technologies to rank them based on performance, reliability, and cost for installation and annual operation and maintenance.

There are two approaches for selecting which systems should be used in Brewster. Specific technologies could be approved for use, or a specific nitrogen removal concentration could be established and systems that are proven to meet this requirement could be chosen by the property owner with approval by the Board of Health.

The factors that need to be considered in selecting an approach include:

- The nitrogen removal capability of the systems selected for use in the program. The nitrogen reduction provided by an advanced system directly impacts how many systems must be upgraded. Fewer systems must be upgraded to meet the TMDL if the systems provide a higher level of nitrogen treatment. Further discussion on the number of systems requiring treatment is provided in the next section.

- The reliability of the chosen systems over the long term. The Town is responsible for ensuring that the TMDL nitrogen reduction goals are met and will need to have oversight of system performance. If the Town chooses to only allow the use of one or more systems, there may be issues if the systems do not provide the expected level of nitrogen treatment. If systems are operated and maintained properly, then the owners of the systems would likely not be liable for not meeting a nitrogen compliance goal as they

installed the system the Town required them to install. One way to manage this concern might be to obtain a performance guarantee from the system manufacturer that states they will guarantee compliance with the nitrogen reduction levels set by the Town. In addition, if the Town decides to select specific systems for use, there will likely need to be a proposal process to properly establish which systems will be used and what price will be provided.

- The cost for system installation, operation and maintenance. The cost for a system that provides a higher level of treatment may be more, and this could play into how many properties will be required to upgrade their system. There will be tradeoffs between cost and performance that the Town will need to consider as the program moves forward.

- The market for nitrogen reducing septic technologies is advancing and there will be changes over time. Therefore, selecting specific technologies may limit the Town from utilizing new technologies that may perform better or offer a cheaper alternative in the future. Establishing a set nitrogen reduction limit would avoid these types of complications.

Number of Properties Requiring and Advanced Onsite System

The level of nitrogen treatment provided by an advanced onsite system and the location of a property in the watershed both factor into how many systems must participate in the program. Some properties are in areas where there is significant attenuation of nitrogen before it reaches Pleasant Bay via groundwater. This occurs in areas where nitrogen in groundwater flows to a pond and then back into groundwater before it discharges to the Bay. This process removes approximately 50% of the nitrogen contained in the groundwater that enters a pond. In some areas in Brewster groundwater flows through multiple ponds before entering the Bay. It may not be worthwhile to install nitrogen treatment systems in areas where this attenuation is taking place.

HW has analyzed how many properties may need to participate in the program based on the level of nitrogen reduction that is needed. This is summarized a memorandum developed by HW (HW, Dec 31, 2018) which shows that most, if not all, of the homes in the subwatersheds where there is no attenuation will need to be upgraded to meet a nitrogen effluent standard of 12 mg/L to comply with the Pleasant Bay TMDL requirements.

Operation and Maintenance (O&M)

The performance of the advanced onsite systems is directly tied to the way they are operated and maintained. Based on conversations with MassDEP, the Town must have oversight of the O&M program to ensure systems are working sufficiently to meet the nitrogen reduction goals of the TMDL. Oversight will likely include monthly visits to confirm the system is operating per the manufacturers' guidelines. These requirements should be incorporated into the General Bylaw and the Board of Health regulation. The details on the required O&M practices will depend on the systems selected for use. The Town could:

- Hire a certified wastewater operator that works for the Town and is responsible for operating all systems upgraded under this program. The value of this option may

depend on how many properties are included in the program and whether there are too many or too few systems for a Town staff person to manage. The financing for this approach could be provided by property owners who pay the town for the O&M of their system.

- Establish a program to review and approve certified operators that contract with property owners to operate and maintain their systems. Under this approach, the Town would need a program to review the O&M work conducted by the approved operators and likely conduct some spot checks to verify systems are operating properly.

- Work with other communities and possibly Barnstable County to establish a regional approach to O&M management. It might be possible to have the County establish a certified operator program that works on behalf of the Town, and other communities on Cape Cod to provide O&M for advanced onsite systems.

Further discussions in Brewster, with Barnstable County and with neighboring Towns are needed to develop and adopt an appropriate O&M process that provides the proper oversight and control by the Town. However, the process is conducted, the Town will require access to each property to inspect and possibly manage the O&M of the systems. The draft General Bylaw incorporates language to address this issue.

Monitoring

Monitoring of all systems that are upgrades will be needed to confirm compliance with the nitrogen reduction goals in the TMDL. HW has discussed the monitoring requirements under the TMDL with MassDEP and the Pleasant Bay Alliance. In the first year, each system will likely need to be monitored quarterly to insure it is operating as intended. In subsequent years, each system will need to be tested annually with effluent samples analyzed for total nitrogen concentrations. Mass DEP recommends that 1/12th (approximately 10%) of the systems installed in the watershed be tested each month. In the first month a random selection of system representing 1/12th of the total would be tested. In month two a second round of systems would be tested. Over a year all the systems would be tested in this fashion. The nitrogen reduction documented in the monitoring plan will be compared to the TMDL goal to confirm the program is working. It is anticipated there will be some variability in the performance of the systems, and it is anticipated that an average nitrogen reduction across all the systems will be used to compare to the TMDL goal. However, data showing a system isn't meeting its performance goal should also be flagged so an operator can inspect the system and bring it into compliance.

In addition, many systems will require additional testing based on the innovative and alternative system regulations in Title 5 (310 CMR 280). New technologies must be approved following these regulations and there are monitoring requirements established by MassDEP for these systems. Depending on the systems used in Brewster there will be a need to evaluate how to incorporate this testing into the TMDL monitoring discussed above.

The Town will be responsible for overseeing the monitoring of the advanced systems to ensure compliance with the TMDL and a program to oversee this work will need to be established. There may be opportunities for collaboration with the Barnstable County Department of Health

and Environment in the collection, recording and evaluation of this data, options the Town should explore.

Annual Watershed Permit Reporting

The implementation of the program will need to be documented in the annual reports that are required under the Pleasant Bay watershed permit. A framework for the annual report should be developed that includes:

- Updates on the adoption of, and any changes to, the regulatory program;
- Reporting on the number of systems installed and their locations in the watershed;
- A summary of the O&M activities during the reporting period; and
- A summary of the monitoring conducted, including calculations of the amount of nitrogen removed relative to the TMDL nitrogen reduction goal.

Financing

As this program is developed there will also need to be discussions within Brewster on how it will be financed. Town involvement in the financing could potentially allow access to State Revolving Fund loans available through the Pleasant Bay permit although, under current requirements, the town would have to have ownership of the onsite systems to be eligible for these funds. Currently, State Revolving Loan Funds (SRF) cannot be used to fund the upgrades to privately owned septic systems. However, DEP is considering revising the program to allow a town to fund upgrades to privately owned systems as the U.S. Environmental Protection Agency which provides the SRF funds to each state allows this to take place. Town involvement also recognizes that residents beyond those property owners in the watershed benefit from the restoration of Pleasant Bay. An in-depth discussion of an equitable financing program should take place at the same time the implementation plan is developed and should involve extensive input from Town Boards and residents.

Next Steps

The implementation plan will evolve as more information on potential advanced systems is available and as the Town Boards and residents get involved in the discussion. The following next steps are recommended based on the information gathered to date:

- Continue to evaluate existing and new advanced nitrogen reducing septic systems, focusing on their performance, reliability, and cost.

- Select an approach for choosing which systems will be used in Brewster. The Town could decide to require new systems to meet a specific performance standard or could select a suite of systems allowed for use under the program based on their performance and reliability.

- Determine an effective approach to oversee the operation and maintenance program for the selected systems to insure they are functioning properly. The Town could run this program themselves, contract out for the services needed or set specific requirements in

the approval of each system. However, it is done, the Town must have oversight of how the systems are maintained to insure they meet their performance goals.

- Finalize the monitoring program based on the specific requirements for the technologies chosen for use in the program.

- Incorporate a strong public participation program in the implementation planning. Regular meetings with the Select Board and Board of Health will be important as well as other outreach activities including public meetings and meetings focused on the property owners affected by the program.

- Continue discussions on how best to finance this program, evaluating public and private funding approaches. This evaluation should be concurrent with the rest of the implementation planning, especially as decisions on the technologies chosen and on the oversight of operation and maintenance will affect the overall project cost.

Pilot Program

If the Town decides to move forward with an onsite septic system program, then they should begin a pilot program to test out the performance of the selection of systems, and the ongoing operation, maintenance and monitoring practices that will be needed. Five to ten sites should be chosen for the installation of pilot systems, with the systems chosen based on the information provided through the Pleasant Bay Alliance SNEP grant analysis. The Town should solicit volunteers to allow the installation on their property. This will give valuable information on installation costs. It will also provide worthwhile experiences with operation and maintenance to guide how this process can best work moving forward. It will also be useful in evaluating the mechanisms for ongoing monitoring of the systems. The Town could begin with an installation at a Town property such as with an upgrade of the septic system at the Captains Golf Course.

References

Horsley Witten Group, Inc. December 31, 2018. Evaluation of the Number of Homes in the Pleasant Bay Watershed That Will Require an Advanced Septic System to Meet the Nitrogen Reduction Goals for the Watershed.

Massachusetts Department of Environmental Protection, May, 2007. Pleasant Bay System Total Maximum Daily Loads For Total Nitrogen (Final Report # 96-TMDL-12, Control #244.0).

Pleasant Bay Alliance, May 2018. Pleasant Bay Targeted Watershed Management Plan http://pleasantbay.org/programs-and-projects/watershed-planning/pleasant-bay-watershed-permit

University of Massachusetts Dartmouth, School of Marine Science and Technology, May 2006. Massachusetts Estuaries Project, Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Pleasant Bay System, Orleans, Chatham, Brewster and Harwich, Massachusetts

Attachment: Draft General Bylaw for Using Innovative/Alternative Septic Systems to Meet the Pleasant Bay TMDL

DRAFT
Town of Brewster, MA
General Bylaw (for Town Meeting approval)

Regulation of Sewage Disposal Systems to Protect Water Quality in Pleasant Bay

This is a preliminary draft of the proposed bylaw developed for discussion purposes. Reader's notes are provided in specific sections to identify issues that need further evaluation and discussion.

1. Purpose and Authority

1.1 This chapter is adopted to comply with the Town of Brewster's obligations pursuant to the Pleasant Bay Watershed Permit, issued by The Massachusetts Department of Environmental Protection (MassDEP) on August 3, 2018 (the "Permit"). The Town has concluded that it is necessary to reduce nitrogen in effluent from on site wastewater disposal systems in order to comply with the Town's obligations under the Permit. These requirements supplement and are in addition to those found in the *State Environmental Code Title 5* (310 CMR 15.00) ("Title 5").

1.2 The Brewster Board of Health is authorized to enforce this chapter and to adopt implementing regulations pursuant to M.G.L. Chapter 111, Section 31 and 127A, as amended to supplement its existing regulations.

The Board of Health will be asked to develop implementing regulations to oversee the upgrade of septic systems in the Pleasant Bay watershed, providing details on the performance of the systems that are installed, the operation and maintenance requirements and monitoring schedules. These regulations can be updated over time based on lessons learned or to incorporate new technologies for nitrogen treatment.

2. Applicability

This regulation shall apply to all existing and proposed subsurface sewage disposal systems located in Subwatershed _____, as shown on Map entitled _____ (the "Map") below. A copy of the Map is on file at the Brewster Board of Health Office at 2198 Main Street, Brewster, Massachusetts

Further work is needed to determine the number and location of properties that will be required to update their septic system. This will depend primarily on the level of nitrogen treatment that can be provided by the advanced systems that will be used.

3. Definitions

Enhanced nitrogen removal system: An alternative or innovative septic system that is approved by MassDEP for general, pilot or provisional use.

Person: An individual, owner, firm, corporation, company, parent company, subsidiary, limited liability company, entity, trust, joint venture, partnership, legal representative, agent or other form of doing business or any other group of individuals or entities and includes the plural as well as the singular.

4. Effluent Treatment Requirements for Septic Systems in Subwatershed _____.

All existing septic systems and any proposed septic systems associated with new construction or expansion of existing development with Subwatershed _____ must be upgraded to comply with these requirements. Existing septic systems shall be upgraded at the time of any transfer in title of the property. All such upgrades, as well as construction of new septic system or expansion of all septic systems with Subwatershed _____ must incorporate an advanced nitrogen removal system approved for use by the MassDEP that will treat septic system effluent to a standard of _____ mg/L of total nitrogen or below. Compliance with the _____mg/L standard must be measured in the effluent after treatment is conducted and before it is discharged into the ground below the leaching facility. All systems must be designed and installed with accessible monitoring ports.

5. Monitoring Requirements

Monitoring must be conducted according to the requirements for the innovative and advanced onsite treatment systems as approved by the Massachusetts Department of Environmental Protection (310 CMR 15.280) and the Board of Health. Monitoring for compliance with the Pleasant Bay Watershed Permit is also required according to requirements that will be established by the Board of Health. Monitoring will be conducted by _____ and all results shall be submitted to the Board of Health.

The Town reserves the right to take over monitoring for any or all systems installed pursuant to this chapter and to assess a fee to property owners to cover the costs of the same.

Monitoring is required to prove that the advanced nitrogen treatment systems are meeting the required performance standards for compliance with the Pleasant Bay Watershed Permit. The Town needs to determine who will be responsible for taking samples, reporting results and paying for the ongoing testing.

6. Operation and Maintenance Requirements

The property owner shall hire a person or firm who is approved by the system manufacturer and the Board of Health to operate the system and perform routine maintenance in accordance with the manufacturer's guidelines along with any additional requirements of MassDEP or the Board of Health. The property owner shall file documentation in the form or reports or receipts of routine maintenance or any repairs with the Board of Health.

The Town reserves the right to take over operations and maintenance for any or all systems installed pursuant to this chapter and to assess a fee to property owners to cover the costs of the same.

The Town needs to decide if Town staff will conduct the system O&M, or if they will approve certified operators that will do the work on behalf of the property owner. There may also be options for regional coordination on system O&M that can be explored.

7. Easements

At the time of system approval by the Board of Health, a property owner must grant an easement to the Town in a form approved by Board of Health to conduct any required monitoring and/or operation and maintenance. All such easements shall be recorded against the property title at the Barnstable County Registry of Deeds or Land Court and shall be structured to allow Town staff and approved system operators to access the property.

8. Enforcement

8.1 The Board of Health, its agents, officers and employees shall have the authority to enter upon privately owned land for the purpose of performing their duties for the administration and review of this regulation and may make or cause to be made such examination, operation and maintenance, surveys or sampling as the Board deems necessary.

8.2 The Board of Health shall have the authority to enforce these regulations by violation notices, administrative order and civil and criminal court actions.

8.3 Any person who shall violate any provision of this regulation for which a penalty is not otherwise provided shall be subject to a fine of not more than $200. Each day or portion thereof during which a violation occurs or continues shall constitute a separate offense.

9. Severability

Each section of these rules and regulations shall be construed as separate and to the end that if any section, item, sentence, clause or phrase shall be held invalid for any reason, the remainder of these rules and regulations shall continue in full force and effect.

10. Effective Date

ATTACHMENT Q

2022 AND 2023 NAMSKAKET MARSH MONITORING REPORTS

Town of Orleans
Wastewater Treatment Facility
Effluent Disposal
Namskaket Marsh –
Salt Marsh Vegetation
Baseline Monitoring Report

Orleans, Massachusetts

Submitted to:

Massachusetts Department of Environmental Protection

Submitted on behalf of:

Town of Orleans

Submitted by:

AECOM

December 23, 2022

AECOM

AECOM
250 Apollo Drive
Chelmsford, MA 01824
www.aecom.com

978 905 2100 tel
978 905 2101 fax

December 23, 2022

Andrew Osei, P.E., Environmental Engineer
Wastewater Management – Cape & Islands
MassDEP Southeast Regional Office
20 Riverside Drive
Lakeville, MA 02347

Subject: **TOWN OF ORLEANS WASTEWATER TREATMENT FACILITY EFFLUENT DISPOSAL NAMKSAKET MARSH - SALT MARSH VEGETATION BASELINE MONITORING REPORT Orleans and Brewster, MA**

Dear Mr. Osei:

On behalf of the Town of Orleans, AECOM is pleased to submit this Namskaket Marsh salt marsh vegetation baseline monitoring report for the Town of Orleans Wastewater Treatment Facility effluent disposal system as required by MassDEP Hydrogeologic Disposal Modification Approval dated September 27, 2021.

As described in the attached baseline monitoring report, a combination of permanent vegetation monitoring plots and aerial ortho-imagery (via drone system) were implemented to document the current assemblage of salt marsh vegetation within the study area. Data collection included vegetative species present and their associated coverages, among other observations. The purpose of the collection of the 2022 baseline vegetation monitoring data is to provide a point of reference for any changes observed within the Namskaket Marsh study area once the Wastewater Treatment Facility (WWTF) and wick well effluent discharge system are in operation.

Please do not hesitate to email me at tom.touchet@aecom.com or call me at (978) 905-3219 if you have any questions. Thank you for your attention to this matter.

Yours sincerely,

Thomas J. Touchet
Sr. Wetland Scientist, PWS
tom.touchet@aecom.com

CC: I. Jarvis, MassDEP
J. Kelly, Town of Orleans (1 copy via e-mail)
T. Parece, AECOM
File

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Attachment A – Namskaket Marsh Vegetation Monitoring Figures

Attachment B – Town of Orleans Wick Discharge Modification Approval

1.0 Introduction

Salt Marsh Vegetation Monitoring Goals

An application for the modification of the design of the wick discharge for the Orleans Wastewater Treatment facility was submitted to MassDEP for approval on June 14, 2021. The application for the modification was approved by MassDEP on September 27, 2021 (Attachment B). In the approval letter, Condition #4 states: "There is possible impact of mounding on the marshes; therefore, monitoring of the species present is recommended prior to discharge to document any potential changes during discharge commencement."

The goal of the proposed salt marsh monitoring is to monitor the plant species distribution within the eastern/southeastern portion of Namskaket Creek prior to and once the discharge commences in order to annually document any shifts in plant cover from salt marsh to freshwater vegetative species, including *Phragmites*. The monitoring program included the establishment of permanent vegetation monitoring plots located within the study area (Attachment A – Figure 1) as well as aerial orthophotography. If any changes to the salt marsh community such as expansion in *Phragmites* cover are documented and believed to be attributable to the WWTP discharge, mitigation should be considered for implementation, with specific remedial measures to be discussed with MassDEP.

Potential Groundwater Mounding Impacts

The Massachusetts Estuaries Project (MEP) determined that nitrate load from existing and future septic loads will need to be removed from the Town Cove Watershed in Orleans Massachusetts to meet the nutrient load reduction targets. The Orleans Water Quality Advisory Panel (OWQAP) evaluated traditional and non-traditional nutrient reduction technologies for nitrate removal within the watershed. Due to the significant nitrate load removal needed within the Town Cove Watershed, the OWQAP proposed to manage a significant portion of the nitrate load through the construction and operation of wastewater collection, treatment, and disposal facilities. Flow from the collection area will be primarily residential and commercial. Construction of the wastewater treatment facility (WWTF) is nearly complete and operation of the subsurface treated effluent disposal system is anticipated to commence soon.

The future design capacity of the WWTF is 350,000 gpd average daily flow. Treated effluent will be discharged below ground via multiple wick wells, which is a method to discharge WWTF effluent to groundwater. Each wick is approximately 52-inches in diameter by 80-feet deep located in the unsaturated portion of the aquifer.

Five wicks have been installed at 32 Lots Hollow Road in Orleans which is the primary discharge location for the WWTF. Potential mounding impacts include the discharge of groundwater in areas where groundwater does not presently discharge and the rise of groundwater levels adjacent to the wick and on surrounding properties. Groundwater mounding and water quality impacts were modeled using worst case input parameters. These included using high water-table conditions and a discharge rate that exceeds the actual discharge rate of the WWTF.

The groundwater mounding simulation suggests that the groundwater table may rise approximately 0.3 feet at a discharge rate of 150,000 gpd and rise up to 1.0 foot at discharge rate of 500,000 gpd at the eastern/southeastern boundary of Namskaket Creek. Similarly, the groundwater model predicts a potential rise of approximately one (150,000 gpd discharge) to four (500,000 gpd discharge) inches at Little Namskaket Creek and north of Namskaket Creek.

Although this groundwater mound prediction is only an approximation, the increase in groundwater elevation in the vicinity of Namskaket and Little Namskaket Creeks has the potential to alter the hydrology of the marsh sufficiently that a vegetation change may occur. The portion of Namskaket Creek that is within the area of the predicted groundwater mound is an area which includes both a saltmarsh as well as a brackish plant community associated with Hurley's Bog on the south side of the Cape Cod Rail Trail.

Typically, the hydrology driving the presence of hydrophytic plant species is located within the top 12-inches of the soil; therefore, a change in this regime of 3 to 12 inches could result in a substantial change to the hydrological conditions experienced by plant species present. Since the discharge would represent an increase in freshwater input to the marsh, it is possible that a shift from salt marsh to freshwater plant species could occur. These conditions would be particularly favorable to an increase in extent of Phragmites, which already exists in the area. However, the extent of any vegetation shift is difficult to predict.

A recent study conducted by USGS (2016) indicated that as a result of sea level rise, groundwater levels on Cape Cod are predicted to rise as high as 2.11 feet, with a more nominal rise of 0.1 foot near inland streams. Given these predictions and the volume of normal daily tidal flow into and out of the Namskaket Marsh that is currently observed, it is likely that any effect of the groundwater mounding predicted to occur as a result of the proposed groundwater discharge would be more than offset by changes likely to occur as a result of sea level rise over a longer time period.

It is possible that floodplains may be slightly affected as the water table may slightly increase in elevation in some low elevation areas around the marshes. It is also possible that floodplain extent

may increase nominally as a result of the groundwater mounding predicted, although any increase would be unlikely to raise the floodplain elevation by a half-foot or more, which would trigger a modification to the mapped floodplain. However, any increase is likely to be dwarfed by predicted sea level rise.

2.0 Methods

The vegetation monitoring program for 2022 (Monitoring Year #1) consisted of field monitoring of vegetation cover within Namskaket Marsh (Attachment A – Figure 1) as described further in detail below. An AECOM certified Professional Wetland Scientist (PWS)/FAA-certified sUAS (drone) pilot conducted the field monitoring effort on July 21 and 22, 2022.

The data collected for this Monitoring Year #1 will be used to evaluate the potential effects of the proposed discharge to groundwater of treated sewage effluent on salt marsh vegetation coverage and distribution within the study area in subsequent years when the WWTF is in operation and discharging to the wick wells. The length of vegetation monitoring plan as outlined in the sections below is anticipated to last five years.

Elements of the 2022 (Monitoring Year #1) vegetation monitoring program include the following:

2.1 Monitoring Plot Setup and Monitoring

Eight (8) permanent vegetation monitoring plots were established in the southern and southeastern portion of salt marsh in Namskaket Marsh (on the north side of the Cape Cod Rail Trail) within the area of potential groundwater mounding (Attachment A – Figure 1). The 8 plots were oriented along two transects (4 plots each), with the western transect oriented perpendicular to the main channel of Namskaket Creek (in a generally northeast to southwest orientation) and the eastern transect generally oriented in a northwest to southeast orientation (Attachment A – Figure 1). Since edges between differing plant communities may likely show changes in vegetation distribution and percent cover before the center of plant communities do in response to changes in environmental conditions, the plot locations were chosen to be on vegetation cover type edges where possible rather than in the center of a cover type. The specific locations of the plots were adjusted slightly in the field as necessary to optimize capturing edge transitions where possible. The center of each plot was be marked with a permanent PVC stake (painted yellow) and surveyed with a survey grade GPS unit. The diameter of each circular plot was 20 feet.

Once the plots were established, vegetation within each 20’ diameter circular plot was assessed for vegetative species present and absolute (total) percent cover of each species (please see Table 1

below). Only live plants were counted toward coverage totals. Other general observations within the plot were also noted on the data sheets (presence of wrack, observations of plant herbivory, disease, mortality, etc. if observed within a particular plot).

2.2 Use of Small Unmanned Aircraft Systems (sUAS) to Support Monitoring

To further support vegetation monitoring, an approximately 5.25 acre area encompassing all eight permanent vegetation plots as well as additional area to the east (along a portion of a Namskaket Creek tributary) was flown on July 20, 2022 with a small Unmanned Aircraft System (i.e. drone system). The purpose of the drone flights was to document vegetative species assemblages aerially via an orthophoto mosaic that contains georeferenced data that was imported into ArcMap GIS. Prior to leaving the field after the UAS flights, spot checks were made to confirm the actual species present that occured in major plant assemblages observed. Once imported into GIS (ArcMap), the aerial photo (orthophoto mosaic) of the study area was analyzed and general plant species communities were demarcated (e.g. *Spartina alterniflora, Spartina patens, Distichlis spicata, Iva frutescens*, *Phragmites australis*, mixes of species thereof, etc.). Aerial coverages of each species or mix of species were calculated for the full study area using GIS (acres and square feet) and tallied Table 2 below.

3.0 Assessment Metrics for Future Monitoring

Changes in vegetation coverage and species composition between the 2022 baseline monitoring event (Monitoring Year #1) and future monitoring events once the effluent discharge system is in full operation will be assessed via two methods: individual vegetation plots and cover type mapping via UAS (drone) aerial imaging using the data collected as described above. This assessment will result in future annual monitoring reports that will include: (1) Introduction; (2) Summary of Existing Information Utilized; (3) Methods; (4) Results and Discussion; and (5) Conclusions. The final reports will be submitted to MassDEP in electronic (PDF) format.

Plot Data

Absolute (total) areal coverage estimates for each species observed in a plot as recorded as a percent of the total 20-foot diameter plot will be compared against species data in successive years for all 8 permanent plots. The comparison will be made in tabular form and chart form for easier viewing. Additional observations will be discussed for each plot that may add additional insight into the dynamics of each plot (e.g. plant herbivory, plant mortality, signs of disease, observations of wrack or other high water events, etc.).

Aerial Data

Estimates of areal coverage by individual species and/or mixes of multiple species within varying vegetation assemblages as demarcated and calculated by area (acres and square feet) in GIS will be compared in successive years in both tabular and chart form.

Annual monitoring of the permanent vegetation plots and orthophoto data collection is anticipated to occur from 2023 to 2026 (5 years of monitoring in total). While changes in species present and their associated coverages are normal within plant communities over time in response to natural variables (coastal storm frequency and duration, evaporation and transpiration, rainfall, temperature, groundwater chemistry, water table fluctuation, etc.), particular attention will be paid to changes involving the loss of salt marsh vegetation and the increase of invasive species coverage. Based upon the results of these comparisons, conclusions will be drawn and remediation may be recommended. Should remediation be necessary, the Town of Orleans will discuss specific remedies with the agencies.

4.0 Baseline Monitoring Results (Monitoring Year #1) and Discussion

As discussed above, this Monitoring Year #1 salt marsh vegetation monitoring report focuses on the results of data collected in July 2022 as a baseline for future comparison of subsequent monitoring event data. Figures 1 and 2 below show the general study area as viewed from the drone system. Both photos were taken on an incoming tide, so the tidal creeks were nearly full at the time. Daily tidal flows appear to be a major factor influencing vegetative species composition and distribution within the study site. Tidal flows were also observed moving a substantial amount of wrack within tidal creeks and along the banks both on incoming and outgoing tides. As seen in Attachment A – Figures 1 and 2, wrack is present in many areas of the study site. Depending on thickness of the wrack, how long it has been in place, and the species of vegetation covered by the wrack, some areas of wrack have smothered what was previously vegetated area, while where the wrack is relatively thin or newly deposited, existing vegetation was observed trying to grow up through the wrack layer. In Plot #1 (summarized in Table 2 below), wrack was thick enough to smother vegetation and prevent new growth.

Table 1 below summarizes the results of each of the eight permanent vegetation monitoring plots. Since each plot is 20 feet in diameter, the area covered by the observations below at each plot are approximately 314 square feet and provide a finer scale assessment of vegetation coverage and health than the aerial assessment discussed further below. While only Plot #6 had a monoculture of smooth cordgrass (*Spartina alterniflora*), all of the other plots had at least two species present. No significant herbivory was observed in any of the plots and all of the vegetation generally appeared healthy.



Figure 1. Aerial view of the Namskaket Marsh study area (looking west) (July 20, 2022).Figure 2. Aerial view of the Namskaket Marsh study area (looking east) (July 20, 2022).



Figure 2. Aerial view of the Namskaket Marsh study area (looking east) (July 20, 2022).



Figure 3. Aerial view of the Namskaket Marsh study area and the main stem of Namskaket Creek (looking south). The Cape Cod rail Trail is visible in the background (July 20, 2022).

Table 1. Namskaket Salt Marsh Monitoring - Vegetation Coverage Results for 20' Diameter Permanent Monitoring Plots (Data collected on July 21, 2022)

			Total Percent Cover of Vegetation by Species within Each Plot							
Scientific Name	***Common Name***	***NWI Indicator Status***	***Plot #1***	***Plot #2***	***Plot #3***	***Plot #4***	***Plot #5***	***Plot #6***	***Plot #7***	***Plot #8***
Bolboschoenus robustus	Sturdy bulrush	OBL	15%	25%						
Distichlis spicata	Saltgrass	FACW	15%				40%			15%
Phragmites australis	Common reed	FACW		25%						
Pluchea odorata	Marsh fleabane	OBL	<1%	<1%						
Salicornia depressa	Virginia glasswort	OBL	<1%	2%		<1%				<1%
Spartina alterniflora	Smooth cordgrass	OBL	7%	10%	70%	70%	45%	100%	75%	60%
Spartina patens	Saltmeadow cordgrass	FACW	40%	25%	85%	50%	65%		45%	75%
		Plot Notes:	No *Spartina alterniflora* in flower. 10-15% wrack, no vegetation visible underneath	25% wrack		Fiddler crabs observed in most of salt marsh. Occasional ducks observed. 5% wrack with *Spartina alterniflora* emerging	15% wrack, composed of *Spartina patens* and *Spartina alterniflora*	2% wrack, Large creek 15 ft to the north. Small channel 2 ft to the west		A portion of a small tidal channel is located along the northwestern periphery of the plot.

NOTE: National Wetland Inventory – National Wetland Plant List Indicator Rating Categories included above are: OBL (Obligate) or FACW (Facultative Wetland). OBL and FACW plants are those that occur in wetlands 99% and %67-99% of the time, respectively.

Table 2 below summarizes the square footages and acres of the various cover types that were identified by creating a high-resolution orthophoto mosaic with the drone system and then processing the data in GIS. Surface water comprised approximately 10 percent of the study area, while upland buffer occupied approximately 13 percent, leaving approximately 77 percent of the remaining area potentially available for growth of salt marsh vegetation. However, areas of wrack of various sizes occupied approximately 6 percent of land area that could have otherwise been colonized by salt marsh vegetation. The vegetative assemblage with the greatest cover was the mix of *Spartina patens, Distichlis spicata,* and *Spartina alterniflora* at approximately 1.12 acres (approximately 21 percent of the study area), followed by near monocultures of *Spartina alterniflora* at 0.76 acres (approximately 14.5 percent of the study area). Near monocultures of Phragmites (*Phragmites australis*) occupied approximately 0.47 acres (approximately 9 percent of the study area) and appear well established. Since Phragmites is the dominant invasive plant at the site, any changes in distribution or areal extent will be closely assessed when comparing the 2022 baseline data to future monitoring events.

Table 2. Areal calculations by Cover Type Category for the Monitoring Year #1 (2022) within the Namskaket Marsh Vegetation Monitoring Study Area.

Cover Type Category	Total Square Feet	Total Acres
Bolboschoenus robustus	110	0.003
Iva frutescens	1,980	0.045
Phragmites australis	20,330	0.467
Salicornia depressa	190	0.004
Spartina alterniflora	33,400	0.764
Spartina patens	30,990	0.712
Spartina sp.	4,930	0.113
Spergularia marina	250	0.006
Mix: *Bolboschoenus robustus, Spartina alterniflora*	2,310	0.53
Mix: *Bolboschoenus robustus, Spartina alterniflora, Pluchea odorata*	13,890	0.319
Mix: *Iva frutescens, Phragmites australis*	2,610	0.06
Mix: *Spartina patens, Distichlis spicata*	550	0.013
Mix: *Spartina patens, Distichlis spicata, Spartina alterniflora*	48,560	1.116
Surface Water	23,990	0.551
Wrack	14,510	0.333
Exposed Sediment	650	0.015
Upland	29,570	0.679
	228,820	**5.253**

5.0 Conclusion

A combination of permanent vegetation monitoring plots, aerial imagery, and subsequent mapping of vegetative communities within the study area at Namskaket Marsh provided useful data to assess baseline conditions for future comparisons of vegetative species composition and areal coverages. Monitoring events are proposed to continue in 2023, 2024, 2025, and 2026, which will further assess plant community composition while the effluent disposal system is in operation. The native salt marsh vegetation currently appears healthy and robust. However, as described above, Phragmites is present within the study area and subsequent monitoring events will assess changes in invasive species coverage and distribution at the site.

Attachment A

Namskaket Marsh Vegetation Monitoring Figures

Figure 1.

TOWN OF ORLEANS
LOTS HOLLOW ROAD
SUBSURFACE EFFLUENT DISCHARGE PROJECT

Namskaket Marsh Vegetation Monitoring
Study Area and Permanent Plot Locations

Orleans and Brewster, MA

0 100 200 Feet

N

SCIARRA LEONARD C

WILLARD DAVID TRS

SHAFTO ROBERT A & JEANETTE

WILLARD DAVID TRS

Tributary to Namskaket Creek

Orleans

Brewster

ORLEANS CONSERVATION TRUST

ORLEANS

SELLKE FRANK W & AMY M

Plot #4
Plot #3
Plot #2
Plot #1

ORLEANS CONSERVATION TRUST

Namskaket Creek

Plot #5
Plot #6
Plot #7
Plot #8

ORLEANS CONSERVATION TRUST

TOWN OF ORLEANS

TOWN OF ORLEANS

Approximately 0.6 miles to effluent disposal site

SBA TOWERS IV LLC

Cape Cod Rail Trail

MASSACHUSETTS COMMONWEALTH OF

KANAGA WILLIAM S & CHRISTOPHER TRUSTEES

Legend

- Plot Center
- Circular Monitoring Plot Boundary
- Transect Lines
- UAS (Drone) Flight Area
- Parcel Boundary
- Town Boundary

D:\mmirabito\Projects\Orleans Projects\MUNI\Orleans_Namskaket Marsh\MapsOrleans-Namskaket Marsh-20221222 Figure 1.mxd

Brewster

Orleans

Plot #4

Plot #3

Plot #2

Plot #1

Plot #8

Plot #7

Plot #6

Plot #5

Namskaket Creek

Cape Cod Rail Trail

Legend

- Plot Center
- Circular Monitoring Plot Boundary
- Transect Lines
- UAS (Drone) Flight Area
- Town Boundary

Vegetative Cover Types

- Bolboschoenus robustus
- Iva frutescens
- Phragmites australis
- Salicornia depressa
- Spartina alterniflora
- Spartina patens
- Spartina sp.
- Spergularia marina
- Mix: Bolboschoenus robustus, Spartina alterniflora
- Mix: Bolboschoenus robustus, Spartina alterniflora, Pluchea odorata
- Mix: Iva frutescens, Phragmites australis
- Mix: Spartina patens, Distichlis spicata
- Mix: Spartina patens, Distichlis spicata, Spartina alterniflora
- Surface Water
- Wrack
- Exposed Sediment
- Upland

Document Path: Z:\G-Drive Folders\Projects\MUNI\Orleans-Namskaket Marsh\Maps\Orleans-Namskaket Marsh-2022-1222 Figure 2.mxd

Figure 2.

TOWN OF ORLEANS - LOTS HOLLOW ROAD SUBSURFACE EFFLUENT DISCHARGE PROJECT

Namskaket Marsh Vegetation Monitoring Vegetation Cover Tpes

Orleans and Brewster, MA

0 25 50 100 150 200 Feet

Attachment B

Town of Orleans - Wick Discharge Modification Approval

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection
Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Kathleen A. Theoharides
Secretary

Martin Suuberg
Commissioner

September 27, 2021

Mr. Thomas E. Parece, P.E.
AECOM Technical Services, Inc.
250 Apollo Drive
Chelmsford, Massachusetts 01824

City/Town: Orleans
RE: Hydrogeologic Disposal Modification
Facility Name: GW#933-0 Orleans WWTF
Authorization Type: Approval

Dear Mr. Parece:

The Massachusetts Department of Environmental Protection (MassDEP) has completed its review of the application for modification of the design of the Wick Discharge for the Orleans Wastewater Treatment facility.

As part of the application submitted by AECOM on June 14, 2021, MassDEP received the following:

1. One (1) Typical Wick Design Plan Sheet with the following Title:

DOWNTOWN AREA WWTF
AND
EFFLUENT DISPOSAL
CONTRACT NO. 2019-1 SRF NO. 4486
SHEET NUMBER 99 C-505

2. A summary of wick volume and surface area calculation sheet

3. The MassDEP approved Lots Hollow Hydrogeological report

Pursuant to 314 CMR 5.09 (1) (f), MassDEP hereby **approves** the modification to the Wicks Design by AECOM subject to the following conditions:

1. The design flow of the proposed groundwater discharge shall not exceed 500,000 gallons per day at either 32 or 43 Lots Hollow Road.

2. The proposed wicks shall be constructed within the footprints indicated on Figures 4 and 5, found in the MassDEP approved Hydrogeologic Report.

3. There are private wells which might be affected by the discharge at the site and will need to connect to the Town of Orleans public water supply or be monitored on an annual basis for adverse impacts.

4. There is possible impact of mounding on the marshes; therefore, monitoring of the species present is recommended prior to discharge to document any potential changes during discharge commencement.

5. An Initial Groundwater Monitoring Well and Groundwater Quality Report must be submitted to this office prior to any discharge of wastewater. This report must include:

    a. a final surveyed site plan with location of the wick wells, all monitoring wells and all appropriate elevation data,

    b. boring logs and well construction details for all monitoring wells, and

    c. the analytical results of the groundwater samples collected from the final groundwater monitoring wells. These results will establish the baseline groundwater quality for the site.

If you have questions regarding the comments and conditions of this approval, please contact Steve Hallem at (617) 292-5681 or Stephen.hallem@state.ma.us .

Sincerely,

Gerard M.R. Martin for:
Brian Dudley, Section Chief
Wastewater Management – Cape and Islands

ecc: Mr. John Kelly
19 School Road
Orleans, MA 02653
jkelly@town.orleans.ma.us

Mr. Ian Catlow
Tighe and Bond, Inc.
446 Main Street
Worcester, MA
ibcatlow@tighebond.com

Mr. Mark Owen
AECOM
9 Jonathon Bourne Drive
Pocasset, MA 02559
mark.owen@aecom.com

DEP/Boston
Attn: Stephen Hallem

Town of Orleans
Wastewater Treatment Facility
Effluent Disposal
Namskaket Marsh –
Salt Marsh Vegetation
Year 2 (2023) Monitoring Report

Orleans, Massachusetts

Submitted to:

Massachusetts Department of Environmental Protection

Submitted on behalf of:

Town of Orleans

Submitted by:

AECOM

November 17, 2023

AECOM

AECOM
250 Apollo Drive
Chelmsford, MA 01824
www.aecom.com

978 905 2100 tel
978 905 2101 fax

November 17, 2023

Andrew Osei, P.E., Environmental Engineer
Wastewater Management – Cape & Islands
MassDEP Southeast Regional Office
20 Riverside Drive
Lakeville, MA 02347

Subject: **TOWN OF ORLEANS WASTEWATER TREATMENT FACILITY EFFLUENT DISPOSAL NAMKSAKET MARSH - SALT MARSH VEGETATION YEAR 2 (2023) MONITORING REPORT Orleans and Brewster, MA**

Dear Mr. Osei:

On behalf of the Town of Orleans, AECOM is pleased to submit this Namskaket Marsh salt marsh vegetation Year 2 (2023) monitoring report for the Town of Orleans Wastewater Treatment Facility effluent disposal system.

As described in the attached 2023 salt marsh vegetation monitoring report, a combination of permanent vegetation monitoring plots and aerial ortho-imagery (via drone system) were implemented to document the current assemblage of salt marsh vegetation within the study area and to provide a comparison to the 2022 baseline data. Data collection included vegetative species present and their associated coverages, among other observations.

The results of the 2023 monitoring event show that natural cycles of wrack deposition (smothering existing vegetation) and removal by tidal flow and coastal storm events are an important factor in influencing vegetative species distribution within the study area. Despite an increase in wrack coverage in 2023, the total coverage of native (non-invasive) salt marsh species remained stable between 2022 and 2023. The actual acreage of Phragmites coverage within the study area (areas that were generally a monoculture of Phragmites) decreased slightly in 2023. The native salt marsh vegetation currently appears healthy and robust.

Please do not hesitate to email me at tom.touchet@aecom.com or call me at (978) 905-3219 if you have any questions. Thank you for your attention to this matter.

Yours sincerely,

Thomas J. Touchet
Sr. Wetland Scientist, PWS
tom.touchet@aecom.com

CC: I. Jarvis, MassDEP
K. Newman, Town of Orleans
G. Meservey, Town of Orleans
T. Harrison, AECOM
J. Doyle-Breen, AECOM
File

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Attachment A – Namskaket Marsh Vegetation Monitoring Figures
Figure 1. Study Area and Permanent Plot Locations – 2022 Baseline Conditions
Figure 2. Vegetation Cover Types – 2022 Baseline Conditions
Figure 3. Study Area and Permanent Plot Locations – 2023 (Year 2)
Figure 4. Vegetation Cover Types – 2023 (Year 2)

Attachment B – Town of Orleans Wick Discharge Modification Approval

1.0 Introduction

The purpose of this memorandum is to document the salt marsh monitoring field work and analysis completed by AECOM Technical Services, Inc. (AECOM) on behalf of the Town of Orleans (Town) in 2023.

Salt Marsh Vegetation Monitoring Goals

An application for the modification of the design of the wick discharge for the Orleans Wastewater Treatment facility was submitted to MassDEP for approval on June 14, 2021. The application for the modification was approved by MassDEP on September 27, 2021 (Attachment A). In the approval letter, Condition #4 states: "There is possible impact of mounding on the marshes; therefore, monitoring of the species present is recommended prior to discharge to document any potential changes during discharge commencement."

The goal of the salt marsh monitoring program is to monitor the plant species distribution within the eastern/southeastern portion of Namskaket Creek prior to and once the discharge has commenced in order to document any shifts in plant cover from salt marsh to freshwater vegetative species, including *Phragmites*. The monitoring program included the establishment and reuse of permanent vegetation monitoring plots located within the study area (Attachment A – Figures 1 and 3) as well as aerial orthophotography. If any changes to the salt marsh community such as expansion in *Phragmites* cover are documented and believed to be attributable to the WWTP discharge, mitigation should be considered for implementation, with specific remedial measures to be discussed with MassDEP.

Potential Groundwater Mounding Impacts

The Massachusetts Estuaries Project (MEP) determined that nitrate load from existing and future septic loads will need to be removed from the Town Cove Watershed in Orleans Massachusetts to meet the nutrient load reduction targets. The Orleans Water Quality Advisory Panel (OWQAP) evaluated traditional and non-traditional nutrient reduction technologies for nitrate removal within the watershed. Due to the significant nitrate load removal needed within the Town Cove Watershed, the OWQAP proposed to manage a significant portion of the nitrate load through the construction and operation of wastewater collection, treatment, and disposal facilities. Flow from the collection area is primarily residential and commercial. Construction of the wastewater treatment facility (WWTF) effluent disposal was substantially completed in March 2023. Operation of the facilities began around the same time.

The capacity of the WWTF is 350,000 gpd average daily flow. Treated effluent is discharged below ground via multiple wick wells, which is a method to discharge WWTF effluent to groundwater. Each

wick is approximately 52-inches in diameter by 80-feet deep located in the unsaturated portion of the aquifer.

Five wicks have been installed at 32 Lots Hollow Road in Orleans which is the primary discharge location for the WWTF. Potential mounding impacts include the discharge of groundwater in areas where groundwater did not previously discharge and the rise of groundwater levels adjacent to the wick and on surrounding properties. Groundwater mounding and water quality impacts were modeled using worst case input parameters. These included using high water-table conditions and a discharge rate that exceeds the actual discharge rate of the WWTF.

The groundwater mounding simulation suggests that the groundwater table may rise approximately 0.3 feet at a discharge rate of 150,000 gpd and rise to 1.0 foot at discharge rate of 500,000 gpd at the eastern/southeastern boundary of Namskaket Creek. Similarly, the groundwater model predicted a potential rise of approximately one (150,000 gpd discharge) to four (500,000 gpd discharge) inches at Little Namskaket Creek and north of Namskaket Creek.

Although this groundwater mound prediction is only an approximation, the increase in groundwater elevation in the vicinity of Namskaket and Little Namskaket Creeks has the potential to alter the hydrology of the marsh sufficiently that a vegetation change may occur. The portion of Namskaket Creek that is within the area of the predicted groundwater mound is an area which includes both a saltmarsh as well as a brackish plant community associated with Hurley's Bog on the south side of the Cape Cod Rail Trail.

Typically, the hydrology driving the presence of hydrophytic plant species is located within the top 12 inches of the soil; therefore, a change in this regime of 3 to 12 inches could result in a substantial change to the hydrological conditions experienced by plant species present. Since the wick well discharge represents an increase in freshwater input to the marsh, it is possible that a shift from salt marsh to freshwater plant species could occur. These conditions would be particularly favorable to an increase in extent of Phragmites, which already exists in the area. However, the extent of any vegetation shift is difficult to predict.

A recent study conducted by USGS (2016) indicated that as a result of sea level rise, groundwater levels on Cape Cod are predicted to rise as high as 2.11 feet, with a more nominal rise of 0.1 foot near inland streams. Given these predictions and the volume of normal daily tidal flow into and out of the Namskaket Marsh that is currently observed, it is likely that any effect of the groundwater mounding predicted to occur as a result of the effluent discharge would be more than offset by changes likely to occur as a result of sea level rise over a longer time period.

2.0 Methods

Monitoring Year #1 data (baseline monitoring) was collected in 2022 prior to the commencement of the WWTF operation and discharge to the wick wells. The vegetation monitoring program for 2023 (Monitoring Year #2) consisted of field monitoring of vegetation cover within Namskaket Marsh (Attachment A – Figure 3) as performed in 2022 and as described further in detail below. An AECOM certified Professional Wetland Scientist (PWS)/FAA-certified sUAS (drone) pilot conducted the field monitoring effort on July 26 and 27, 2023.

The data collected for this Monitoring Year #2 was compared to data collected in Monitoring Year #1 to evaluate the potential effects of the proposed discharge to groundwater of treated sewage effluent on salt marsh vegetation coverage and distribution within the study area. Any additional monitoring in subsequent years can be compared to the 2022 baseline data. The frequency and timing of future monitoring will be determined by the Town.

Elements of the Monitoring Year #2 (2023) vegetation monitoring program are described in the following sections.

2.1 Monitoring Plot Setup and Monitoring

In Monitoring Year #1, eight (8) permanent vegetation monitoring plots were established in the southern and southeastern portion of salt marsh in Namskaket Marsh (on the north side of the Cape Cod Rail Trail) within the area of potential groundwater mounding (Attachment A – Figure 1). The 8 plots were oriented along two transects (4 plots each), with the western transect oriented perpendicular to the main channel of Namskaket Creek (in a generally northeast to southwest orientation) and the eastern transect generally oriented in a northwest to southeast orientation (Attachment A – Figure 1). Since edges between differing plant communities may likely show changes in vegetation distribution and percent cover before the center of plant communities do in response to changes in environmental conditions, the plot locations were chosen to be on vegetation cover type edges where possible rather than in the center of a cover type. The specific locations of the plots were adjusted slightly in the field as necessary to optimize capturing edge transitions where possible. The center of each plot was marked with a permanent PVC stake (painted yellow) and surveyed with a survey grade GPS unit. The diameter of each circular plot is 20 feet.

In Year #2, an AECOM PWS returned to reassess the vegetation within the same eight permanent vegetation monitoring plots following the same protocol as in 2022. Vegetation within each 20’ diameter circular plot was assessed for vegetative species present and absolute (total) percent cover of each species. Only live plants were counted toward coverage totals. Other general observations within the

plot were also noted on the data sheets (presence of wrack, observations of plant herbivory, disease, mortality, etc. if observed within a particular plot). These results were compared to the 2022 baseline (Year #1) results in Table 1.

2.2 Use of Small Unmanned Aircraft Systems (sUAS) to Support Monitoring

An approximately 5.25-acre area encompassing all eight permanent vegetation plots as well as additional area to the east (along a portion of a Namskaket Creek tributary) was flown on July 26, 2023, with a small Unmanned Aircraft System (i.e. drone system), similar to Monitoring Year #1. The purpose of the drone flights was to document vegetative species assemblages aerially via an orthophoto mosaic (aerial photography) that contained georeferenced data and that is able to be analyzed in GIS. Prior to leaving the field after the UAS flights, spot checks were made to confirm the actual species present that occurred in major plant assemblages observed and the locations of the sot check observations were recorded with a GPS system. Once imported into GIS (ArcMap), the aerial photography of the study area along with the positions of the spot check observations were analyzed and general plant species communities were demarcated (e.g. *Spartina alterniflora, Spartina patens, Distichlis spicata, Iva frutescens*, *Phragmites australis*, mixes of species thereof, locations of wrack, etc.). Aerial coverages of each species or mix of species along with areas covered by wrack, areas of open water, etc. were calculated for the full study area using polygons created in GIS (acres and square feet). Table 2 summarizes those calculations and compares Year #1 and Year #2 cover type category square footages and acreages to identify changes in coverage categories.

3.0 Assessment Metrics for Monitoring

With the effluent discharge system now in full operation, changes in vegetation coverage and species composition between the 2022 baseline monitoring event (Monitoring Year #1) and the 2023 monitoring event (Monitoring Year #2) were assessed via two methods: individual permanent vegetation plots and cover type mapping via UAS (drone) aerial imaging using the data collected as described above.

Vegetation Monitoring Plot Data

Absolute (total) areal coverage estimates for each species observed in a plot were recorded as a percent of the total 20-foot diameter plot. These estimates from 2022 and 2023 were compared for all 8 permanent plots and summarized in Table 1. Additional observations are discussed below as applicable for each plot that may add additional insight into the dynamics of each plot (e.g. plant mortality, observations of wrack, etc.).

Aerial Image Data

Estimates of areal coverage by individual species and/or mixes of multiple species within varying vegetation assemblages were demarcated and calculated by area in GIS. These calculations from 2022 and 2023 were compared below in Table 2. Mapped coverage polygons are provided in Attachment A.

Species and their coverage areas change over time for a number of reasons (i.e. coastal storm frequency and duration, evaporation and transpiration, rainfall, temperature, groundwater chemistry, water table fluctuation, etc.). Changes involving the loss of salt marsh vegetation and the increase of invasive species coverage are the focus of these monitoring periods.

4.0 Monitoring Results (Monitoring Year #2) and Discussion

This Monitoring Year #2 salt marsh vegetation monitoring report focuses on the results of data collected in July 2023 and the comparison to the July 2022 baseline monitoring data. Figures 1, 3, and 5 below show representative aerial photos (taken via drone) of the general study area in July 2022. For comparison, Figures 2, 4, and 6 show similar aerial views of the same representative areas as observed in July 2023. In July 2022, the aerial photos were taken on an incoming tide, so the tidal creeks were nearly full at the time. The aerial photos taken in July 2023 were taken near low tide, so more of the tidal channel banks were exposed at the time of the drone flights.



Figure 1. Aerial view of the Namskaket Marsh study area (looking west) (July 20, 2022).



Figure 2. Aerial view of the Namskaket Marsh study area (looking east) (July 26, 2023).



Figure 3. Aerial view of the Namskaket Marsh study area (looking east) (July 20, 2022).



Figure 4. Aerial view of the Namskaket Marsh study area (looking east) (July 26, 2023).



Figure 5. Aerial view of the Namskaket Marsh study area and the main stem of Namskaket Creek (looking south). The Cape Cod rail Trail is visible in the background (July 20, 2022).



Figure 6. Aerial view of the Namskaket Marsh study area and the main stem of Namskaket Creek (looking south). The Cape Cod rail Trail is visible in the middle of the photo (July 26, 2023).

4.1 Comparison of 2022 and 2023 Monitoring Results: Vegetation Monitoring Plots

Table 1 below summarizes the results of each of the eight permanent vegetation monitoring plots for 2022 (Year #1 baseline) and 2023 (Year #2). The data were collected on July 21, 2022, and July 26 & 27, 2023. Since each plot is 20 feet in diameter, the area covered by the observations below at each plot are approximately 314 square feet and provide a finer scale assessment of vegetation coverage and health than the larger-scale cover type aerial assessment. While relatively minor changes had occurred to individual species' coverages in some of the plots, no significant herbivory was observed in any of the plots and the vegetation generally appeared healthy.

The minor changes observed did not appear to be the result of potential groundwater mounding. Daily tidal flows appear to be a major factor influencing vegetative species composition and distribution within the study site. Tidal flows at the study site have been observed moving a substantial amount of wrack within tidal creeks and along the banks both on incoming and outgoing tides. As seen in Attachment A, wrack is present in many areas of the study site in both 2022 and 2023. High tides and coastal storms affect the amount and distribution of the wrack coverage observed. Depending on thickness of the wrack, how long it has been in place, and the species of vegetation covered by the wrack, some areas of wrack have smothered what was previously vegetated area, while where the wrack is relatively thin or newly deposited, existing vegetation was observed trying to grow up through the wrack layer in both 2022 and 2023. The effects of wrack when present in a plot are included in the discussion below.

Table 1. Namskaket Salt Marsh Monitoring – Percent Vegetation Coverage Results for 20' Diameter Permanent Monitoring Plots (data collected on July 21, 2022 and July 26 & 27, 2023)

Scientific Name		*Bolboschoenus robustus*	*Distichlis spicata*	*Phragmites australis*	*Pluchea odorata*	*Salicornia depressa*	*Spartina alterniflora*	*Spartina patens*
Common Name		Sturdy Bulrush	Saltgrass	Common reed	Marsh fleabane	Virginia glasswort	Smooth cordgrass	Saltmeadow cordgrass
NWI Indicator Status*		OBL	FACW	FACW	OBL	OBL	OBL	FACW
Plot #1	2022	15	15		<1	<1	7	40
	2023	1	15		1	<1	10	60
	% Change	-14	0		0	0	3	20
Plot #2	2022	25	<1	25	<1	2	10	25
	2023	5	<1	25	1	<1	15	25
	% Change	-20	0	0	0	-2	5	0
Plot #3	2022						70	85
	2023		<1				60	75
	% Change		1				-10	-10
Plot #4	2022					<1	70	50
	2023					0	75	50
	% Change					-1	5	0
Plot #5	2022		40				45	65
	2023		10				55	70
	% Change		-30				10	5
Plot #6	2022						100	
	2023						100	
	% Change						0	
Plot #7	2022		<1				75	45
	2023		<1				80	35
	% Change		0				5	-10
Plot #8	2022		15			<1	60	75
	2023		10			<1	60	75
	% Change		-5			0	0	0

* National Wetland Inventory – National Wetland Plant List Indicator Rating Categories included above are: OBL (Obligate) or FACW (Facultative Wetland). OBL and FACW plants are those that occur in wetlands 99% and %67-99% of the time, respectively.

Plot #1

All species that were present in Plot #1 in 2022 were also observed in 2023. Although Plot #1 experienced a decrease in *Bolboschoenus robustus* coverage (partially the result of wrack coverage), this reduction was replaced by increases in *Spartina patens* and *Spartina alterniflora* in other portions of the plot resulting in an overall increase in native salt marsh species coverage within the plot. While

Bolboschoenus robustus is a native obligate plant species, *Spartina alterniflora* and *Spartina patens* are also both native, and are OBL and FACW respectively.

Plot #2

Approximately 30% of the plot was smothered by wrack, resulting in decreases in coverage from 2022 to 2023 of *Bolboschoenus robustus* and *Salicornia depressa*. *Spartina alterniflora* increased by 5% in total coverage. One of the goals of the year-to-year comparison is to assess changes in non-native plant communities. Plot #2 is the only permanent plot in which *Phragmites australis* was recorded in the initial baseline monitoring and in 2023. Although *Phragmites australis* had a percent cover of 25% in 2023, there was no increase from the baseline monitoring percent cover, suggesting that environmental variables in 2023 did not provide an advantage for Phargmites expansion into the adjacent native salt marsh plant community in Plot #2.

Plot #3

There were 10% decreases to both *Spartina alterniflora* and *Spartina patens* observed in Plot #3. It was also observed that there was approximately 20% cover of dead *Spartina patens* that other *Spartina alterniflora* and *Spartina patens* were struggling to emerge through. It is likely that the death of a portion of the *Spartina patens* patch was the result of wrack coverage that was deposited earlier in the growing season but has since been moved by tidal/storm action.

Plot #4

There were relatively small changes observed between 2022 and 2023 at Plot #4. Although there was a small amount of coverage (<1%) of *Salicornia depressa* in 2022, none were observed in 2023. Although a 5% increase in the coverage of *Spartina* alterniflora was observed in the plot, the coverage of *Spartina patens* remained unchanged at 50%.

Plot #5

Although *Distichlis spicata* coverage decreased from 40% to 10% cover, coverages of *Spartina alterniflora* and *Spartina patens* increased 10% and 5% respectively. Approximately 15% of the surface area of Plot #5 was exposed substrate in 2023. This percentage correlates well with the 15% of wrack observed in the plot in 2022. It is likely that the wrack that was present in 2022 smothered the vegetative species below it and was subsequently removed by tidal or coastal storm activity and the bare substrate has not yet had enough time to recolonize.

Plot #6

Plot # 6 was dominated by a *Spartina alterniflora* monoculture in both 2022 and 2023 and no changes have been observed (coverage remains at 100%). A small amount of wrack was observed amongst the Spartina alterniflora but did not appear to affect growth within the plot.

Plot #7

Spartina alterniflora and *Spartina patens* dominated the plot in 2022 and 2023. A third species, *Distichlis spicata*, remained unchanged at less than 1% coverage. A slight (5%) increase in cover of *Spartina alterniflora* was observed while a 10% decrease in *Spartina patens* was noted. The decrease in live *Spartina patens* observed in July 2023 correlates to what appeared to be previous smothering by wrack earlier in the season that is no longer present.

Plot #8

The only change in vegetative coverage in Plot #8 between 2022 and 2023 was a slight decrease (5%) in *Distichlis* spicata coverage. This can be attributed to smothering by new wrack observed in the plot in July 2023.

Overall, there were no changes in plant species composition within the permanent vegetation monitoring plots that indicate negative effects from the wastewater treatment plant effluent discharge on native salt marsh plant community distribution or composition. As discussed above, the only observed *Phragmites australis* located within a plot was in Plot #2, and there was no change in percent coverage from the baseline monitoring year. There were no other invasive species observed in the plots or establishment of new native species that prefer lower saline conditions. All plots demonstrated characteristics of healthy salt marsh habitat. While there were some changes in plant composition from plot to plot, this is likely attributable to the dynamic nature of salt marsh ecosystems, particularly the deposition and removal of wrack.

4.2 Comparison of 2022 and 2023 Monitoring Results: Vegetation Cover Type Mapping

Table 2 below summarizes the square footage of the various cover types for 2022 and 2023. Table 2 also includes a comparison of the percentage of the total study area and changes for each cover type between 2023 and the 2022.

Changes to cover type boundaries and species assemblages within cover types are anticipated to occur to various degrees over time as a natural response of the salt marsh vegetation to a host of natural environmental variables. However, changes that occur to the salt marsh study area that include a

significant expansion in invasive species such as Phragmites or significant death of native salt marsh species (other than the result of smothering by wrack or other natural processes (e.g. winter erosion from ice sheets)) is not desirable.

As discussed above, the deposition and removal of wrack within the study area by tidal flows and coastal storms is a major factor affecting plant species coverages and distribution within the salt marsh study area. The amount and distribution of wrack was clearly seen in the 2023 study area orthophoto mosaic. When comparing the areal extent of wrack between 2022 and 2023, the actual amount of wrack increased from approximately 6.3% to 7.9% of the total area within the study area (an increase in more than 3,400 square feet of wrack) which resulted in additional smothering of existing vegetation within the study area. The actual acreage of Phragmites coverage within the study area (areas that were generally a monoculture of Phragmites) decreased slightly in 2023 from approximately 8.9% to 8.8% of the total study area, partly because of the presence of wrack and partly because of the slight expansion of native salt marsh vegetation along their boundaries with Phragmites.

While the acreage of surface water appeared to decrease in 2023, this was partly due to the orthophoto mosaic being flown near low tide as opposed to near high tide in 2022 when tidal creeks and smaller tributaries were near bankfull conditions and shallow pools within the salt marsh were full.

Three new cover type categories were added in 2023, including: "*Distichlis spicata"* (a saltgrass monoculture), "*Suaeda maritima"* (a sea-blite monoculture), and "Mix: *Bolboschoenus robustus, Typha angustifolia*" (located in the western portion of the study area near the upland boundary).

The apparent reduction in areal coverage for some of the native salt marsh vegetation cover types is partially due to an increase in wrack. In addition, there were some shifts in boundaries of native species cover types such that a loss of areal extent of one native cover type polygon was a gain in size of an adjacent native species assemblage polygon. When grouping all of the native salt marsh species coverages, desirable salt marsh vegetative coverages remained nearly unchanged between 2022 and 2023 at 59.94% and 59.26%, respectively, despite an increase in wrack coverage at the study site. Based upon these results, the salt marsh appears stable between 2022 and 2023 with no net expansion in invasive species coverage.

Table 2. Areal calculations by Cover Type Category for the Monitoring Year #1 (2022) and Monitoring Year #2 (2023) within the Namskaket Marsh Vegetation Monitoring Study Area.

	Type	2022: Total Square Feet	2022: Percent of Total Study Area	2023: Total Square Feet	2023: Percent of Total Study Area	Square Foot Change
Salt Marsh Vegetative Cover Types	*Bolboschoenus robustus*	110	0.05%	930	0.41%	820
	Distichlis spicata	**N/A**	**N/A**	**129**	0.06%	**129**
	Iva frutescens	1,980	0.87%	1838	0.80%	-142
	Phragmites australis	20,330	8.88%	20037	8.76%	-293
	Salicornia depressa	190	0.08%	171	0.07%	-19
	Spartina alterniflora	33,400	14.60%	32686	14.28%	-714
	Spartina patens	30,990	13.54%	31415	13.73%	425
	Spartina sp.	4,930	2.15%	4913	2.15%	-17
	Spergularia marina	250	0.11%	248	0.11%	-2
	Suaeda maritima	**N/A**	**N/A**	**26**	0.01%	**26**
	Mix: *Bolboschoenus robustus, Spartina alterniflora*	2,310	1.01%	1796	0.78%	-514
	Mix: *Bolboschoenus robustus, Spartina alterniflora, Pluchea*	13,890	6.07%	13194	5.77%	-696
	Mix: *Bolboschoenus robustus, Typha angustifolia*	**N/A**	**N/A**	**122**	0.05%	**122**
	Mix: *Iva frutescens, Phragmites australis*	2,610	1.14%	2620	1.15%	10
	Mix: *Spartina patens, Distichlis spicata*	550	0.24%	707	0.31%	157
	Mix: *Spartina patens, Distichlis spicata, Spartina alterniflora*	48,560	21.22%	47431	20.73%	-1,129
	Surface Water	23,990	10.48%	22375	9.78%	-1,615
	Wrack	14,510	6.34%	17964	7.85%	3,454
	Exposed Sediment	650	0.28%	648	0.28%	-2
	Upland	29,570	12.92%	29570	12.92%	0
	Totals=	***228,820***	***100.00%***	***228820***	***100.00%***	
			59.94%		59.26%	

NOTE: Vegetative cover types shown as **green** text above are new cover types for 2023.

5.0 Conclusion

A combination of permanent vegetation monitoring plots, aerial imagery, and subsequent mapping of vegetative communities within the study area at Namskaket Marsh provided useful data to compare vegetative species composition and areal coverages observed in 2023 to those observed in 2022. Shifts in species composition and coverage appear to be attributable to natural processes of wrack deposition and removal. Phragmites is noted to be present within the study area but has not expanded between the two monitoring periods. Overall, the native salt marsh vegetation appears healthy and robust. Any future monitoring will further assess plant community composition over time.

Attachment A

Namskaket Marsh Vegetation Monitoring Figures

Figure 1.

TOWN OF ORLEANS
LOTS HOLLOW ROAD
SUBSURFACE EFFLUENT DISCHARGE PROJECT

Namskaket Marsh Vegetation Monitoring
Study Area and Permanent Plot Locations
2022 - Baseline Conditions

Orleans and Brewster, MA

0 100 200 Feet

N

SCIARRA LEONARD C

WILLARD DAVID TRS

SHAFTO ROBERT A & JEANETTE

WILLARD DAVID TRS

Tributary to Namskaket Creek

Orleans

Brewster

ORLEANS CONSERVATION TRUST

ORLEANS

SELLKE FRANK W & AMY M

Plot #4
Plot #3
Plot #2
Plot #1

ORLEANS CONSERVATION TRUST

Namskaket Creek

Plot #5
Plot #6
Plot #7
Plot #8

ORLEANS CONSERVATION TRUST

TOWN OF ORLEANS

TOWN OF ORLEANS

Approximately 0.6 miles to effluent disposal site

SBA TOWERS IV LLC

Cape Cod Rail Trail

MASSACHUSETTS COMMONWEALTH OF

KANAGA WILLIAM S & CHRISTOPHER TRUSTEES

Legend

- Plot Center
- Circular Monitoring Plot Boundary
- Transect Lines
- UAS (Drone) Flight Area
- Parcel Boundary
- Town Boundary

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Brewster

Orleans

Plot #4

Plot #3

Plot #2

Plot #1

Plot #8

Plot #7

Plot #6

Plot #5

Namskaket Creek

Cape Cod Rail Trail

Legend

- Plot Center
- Circular Monitoring Plot Boundary
- Transect Lines
- UAS (Drone) Flight Area
- Town Boundary

Vegetative Cover Types

- Bolboschoenus robustus
- Iva frutescens
- Phragmites australis
- Salicornia depressa
- Spartina alterniflora
- Spartina patens
- Spartina sp.
- Spergularia marina
- Mix: Bolboschoenus robustus, Spartina alterniflora
- Mix: Bolboschoenus robustus, Spartina alterniflora, Pluchea odorata
- Mix: Iva frutescens, Phragmites australis
- Mix: Spartina patens, Distichlis spicata
- Mix: Spartina patens, Distichlis spicata, Spartina alterniflora
- Surface Water
- Wrack
- Exposed Sediment
- Upland

Figure 2.

TOWN OF ORLEANS - LOTS HOLLOW ROAD SUBSURFACE EFFLUENT DISCHARGE PROJECT

Namskaket Marsh Vegetation Monitoring
Vegetation Cover Types
2022 - Baseline Conditions

Orleans and Brewster, MA

0 25 50 100 150 200 Feet

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Figure 3.

TOWN OF ORLEANS
LOTS HOLLOW ROAD
SUBSURFACE EFFLUENT DISCHARGE PROJECT

2023 (Year 2) Namskaket Marsh Vegetation Monitoring Study Area and Permanent Plot Locations

Orleans and Brewster, MA

0 100 200 Feet

SCIARRA LEONARD C
WILLARD DAVID TRS
SHAFTO ROBERT A & JEANETTE
WILLARD DAVID TRS
Tributary to Namskaket Creek
Orleans
Brewster
ORLEANS CONSERVATION TRUST
ORLEANS
SELLKE FRANK W & AMY M
Plot #4
Plot #3
Plot #2
Plot #1
ORLEANS CONSERVATION TRUST
Namskaket Creek
Plot #5
Plot #6
Plot #7
Plot #8
ORLEANS CONSERVATION TRUST
TOWN OF ORLEANS
TOWN OF ORLEANS
Approximately 0.6 miles to effluent disposal site
SBA TOWERS IV LLC
Cape Cod Rail Trail
MASSACHUSETTS COMMONWEALTH OF
KANAGA WILLIAM S & CHRISTOPHER TRUSTEES

Legend

- Plot Center
- Circular Monitoring Plot Boundary
- Transect Lines
- UAS (Drone) Flight Area
- Parcel Boundary
- Town Boundary

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Brewster

Orleans

Plot #4

Plot #3

Plot #2

Plot #1

Plot #8

Plot #7

Plot #6

Plot #5

Namskaket Creek

Cape Cod Rail Trail

Legend

Type

- Plot Center
- Circular Monitoring Plot Boundary
- Transect Lines
- UAS (Drone) Flight Area

Type

- Bolboschoenus robustus
- Distichlis spicata
- Iva frutescens
- Phragmites australis
- Salicornia depressa
- Spartina alterniflora
- Spartina patens
- Spartina sp.
- Spergularia marina
- Suaeda maritima
- Mix: Bolboschoenus robustus, Spartina alterniflora
- Mix: Bolboschoenus robustus, Spartina alterniflora, Pluchea odorata
- Mix: Bolboschoenus robustus, Typha angustifolia
- Mix: Iva frutescens, Phragmites australis
- Mix: Spartina patens, Distichlis spicata
- Mix: Spartina patens, Distichlis spicata, Spartina alterniflora
- Surface Water
- Wrack
- Exposed Sediment
- Upland
- Town Boundary

Figure 4.

TOWN OF ORLEANS - LOTS HOLLOW ROAD SUBSURFACE EFFLUENT DISCHARGE PROJECT

Namskaket Marsh Vegetation Monitoring Year 2 (2023) - Vegetation Cover Types

Orleans and Brewster, MA

0 25 50 100 150 200 Feet

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Attachment B

Town of Orleans - Wick Discharge Modification Approval

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection
Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Kathleen A. Theoharides
Secretary

Martin Suuberg
Commissioner

September 27, 2021

Mr. Thomas E. Parece, P.E.
AECOM Technical Services, Inc.
250 Apollo Drive
Chelmsford, Massachusetts 01824

City/Town: Orleans
RE: Hydrogeologic Disposal Modification
Facility Name: GW#933-0 Orleans WWTF
Authorization Type: Approval

Dear Mr. Parece:

The Massachusetts Department of Environmental Protection (MassDEP) has completed its review of the application for modification of the design of the Wick Discharge for the Orleans Wastewater Treatment facility.

As part of the application submitted by AECOM on June 14, 2021, MassDEP received the following:

1. One (1) Typical Wick Design Plan Sheet with the following Title:

DOWNTOWN AREA WWTF
AND
EFFLUENT DISPOSAL
CONTRACT NO. 2019-1 SRF NO. 4486
SHEET NUMBER 99 C-505

2. A summary of wick volume and surface area calculation sheet

3. The MassDEP approved Lots Hollow Hydrogeological report

Pursuant to 314 CMR 5.09 (1) (f), MassDEP hereby **approves** the modification to the Wicks Design by AECOM subject to the following conditions:

1. The design flow of the proposed groundwater discharge shall not exceed 500,000 gallons per day at either 32 or 43 Lots Hollow Road.

2. The proposed wicks shall be constructed within the footprints indicated on Figures 4 and 5, found in the MassDEP approved Hydrogeologic Report.

3. There are private wells which might be affected by the discharge at the site and will need to connect to the Town of Orleans public water supply or be monitored on an annual basis for adverse impacts.

4. There is possible impact of mounding on the marshes; therefore, monitoring of the species present is recommended prior to discharge to document any potential changes during discharge commencement.

5. An Initial Groundwater Monitoring Well and Groundwater Quality Report must be submitted to this office prior to any discharge of wastewater. This report must include:

    a. a final surveyed site plan with location of the wick wells, all monitoring wells and all appropriate elevation data,

    b. boring logs and well construction details for all monitoring wells, and

    c. the analytical results of the groundwater samples collected from the final groundwater monitoring wells. These results will establish the baseline groundwater quality for the site.

If you have questions regarding the comments and conditions of this approval, please contact Steve Hallem at (617) 292-5681 or Stephen.hallem@state.ma.us .

Sincerely,

Gerard M.R. Martin for:
Brian Dudley, Section Chief
Wastewater Management – Cape and Islands

ecc: Mr. John Kelly
19 School Road
Orleans, MA 02653
jkelly@town.orleans.ma.us

Mr. Ian Catlow
Tighe and Bond, Inc.
446 Main Street
Worcester, MA
ibcatlow@tighebond.com

Mr. Mark Owen
AECOM
9 Jonathon Bourne Drive
Pocasset, MA 02559
mark.owen@aecom.com

DEP/Boston
Attn: Stephen Hallem

ATTACHMENT R

REPORT ON THE FEASIBILITY OF NITROGEN REMOVAL CREDITS

PLEASANT BAY ALLIANCE

Report on the Feasibility of Nitrogen Removal Credits Related to Stormwater Management

Task 2 of the Regional Watershed Permit Implementation Project funded by EPA Southeast New England Program (SNEP--2020)



Prepared by:

WRIGHT-PIERCE
Engineering a Better Environment

Wright-Pierce
600 Federal Street
Andover, MA 01810
March 24, 2023

PLEASANT BAY ALLIANCE

Implementing the Watershed Permit:

Report on the Feasibility of Nitrogen Removal Credits Related to Stormwater Management

Task 2 of the Regional Watershed Permit Implementation Project funded by EPA Southeast New England Program (SNEP--2020)

March 24, 2023

INTRODUCTION

The four towns in the Pleasant Bay watershed (Brewster, Chatham, Harwich, and Orleans) all contribute nitrogen to the Bay from various sources including on-site septic systems, lawn and golf course fertilization, and stormwater disposal. These nitrogen loads exceed the assimilative capacity of the Bay, resulting in water quality impairment. After completion of a Targeted Watershed Management Plan (TWMP), the four towns were granted a Watershed Permit by Massachusetts DEP in 2018 that specifies each town's responsibility to reduce its nitrogen loadings to reach the thresholds loads associated with restored water quality and habitat in the Bay.

Each town has established a nitrogen control plan aimed at removing nitrogen loads to meet the Watershed Permit. The current town plans rely on nitrogen removals via public sewers, residential fertilizer controls, golf course fertilizer management, shellfish harvesting, permeable reactive barriers and on-site denitrification systems. None of the towns' formal plans includes an initiative to remove nitrogen from stormwater, given its relatively small percentage of overall nitrogen loads.

While towns move forward to address their responsibilities under the Watershed Permit, they are also seeking to comply with the state/federal requirements related to the General Permit for Stormwater Discharges from Municipal Small Separate Stormwater Systems (MS4) under the federal National Pollutant Discharge Elimination System. Might the MS4-required stormwater management activities remove enough nitrogen to warrant a credit under the Watershed Permit? It is this question that is covered by an EPA grant under the Southeast New England Program (SNEP) awarded to the Pleasant Bay Alliance in 2020. This report is the culmination of that study that addresses this question.

PROJECT APPROACH

This report documents the steps taken to estimate the likelihood that stormwater management activities in the Pleasant Bay watershed can be documented to allow the Towns to take credit for their activities, particularly MS4 measures, within the Watershed Permit. Those steps include:

1. Summarize the impervious area nitrogen loads that were included in the basis for determining nitrogen removals needed to meet TMDLs.

2. Select two sub-watersheds as a basis for reporting on town activities and characterize the specific stormwater management that is occurring there.
3. Identify the MS4 requirements that the towns are meeting or will be meeting and quantify the likely nitrogen removals.
4. Review the EPA performance curves for structural BMPs and suggest enhancements to those curves for conditions on Cape Cod where infiltration must be considered as a pathway for nitrogen reaching the embayment.
5. Estimate the stormwater nitrogen removals in the two sample sub-watersheds and compare the amounts removed with the loads that are the basis for the Watershed Permit
6. Draw conclusions on the relative magnitude of stormwater management activities within the overall watershed nitrogen load and the load removals to which the towns have committed.

STORMWATER NITROGEN LOADS BY SUB-WATERSHED

The primary documentation of nitrogen loads and loading thresholds is the 2006 report *Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Pleasant Bay System, Orleans, Chatham, Brewster and Harwich, Massachusetts.* This report was prepared by UMass-Dartmouth under the Massachusetts Estuary Program (MEP). Portions of this MEP report were updated in 2008 and 2010, primarily to incorporate more accurate data on land use and water use in Harwich.

In the 2010 MEP update, the Bay-wide attenuated watershed load was estimated to be 48,500 kilograms per year (kg/yr) with the following distribution of sources:

- Septic systems 75%
- Lawn and golf course fertilization 16%
- Stormwater 9%

The MEP report established threshold loadings in 19 sub-watersheds that total 30,800 kg/yr. This indicates a removal need of 17,700 kg/yr, with individual town responsibilities ranging from 13% to 39% of the total.

Table 1 lists the un-attenuated and attenuated stormwater nitrogen loads for the 19 sub-watersheds as per the 2006 MEP report. Totals are as follows:

- Un-attenuated stormwater loads 4,074 kg/yr (8,983 lb/yr)
- Attenuated stormwater loads 3,796 kg/yr (8,370 lb/yr)

The attenuation percentages are 10% or higher in seven sub-watersheds and less than 5% in nine sub-watersheds. The aggregate attenuation is about 7%.

Table 1. Pleasant Bay Nitrogen Loads from Impervious Area Runoff (From MEP--2006)

Sub-Watershed	Stormwater N Loads, kg/yr		Percentage of Bay-Wide Atten. Stormwater Load
	Unattenuated	Attenuated	
Meetinghouse Pond	**193**	**193**	**5.1%**
Lonnies Pond	87	48	1.3%
Areys Pond	58	38	1.0%
The River--Upper	87	69	1.8%
The River--Lower	144	121	3.2%
Namequoit River	97	83	2.2%
Pah Wah Pond	50	50	1.3%
Quanset Pond	71	52	1.4%
Round Cove	**154**	**153**	**4.0%**
Muddy Creek--Upper*	395	379	10.0%
Muddy Creek--Lower*	381	356	9.4%
Ryder's Cove*	357	313	8.2%
Crows Pond	147	147	3.9%
Bassing Harbor	51	50	1.3%
Frost Fish Ck	104	104	2.7%
Pochet	269	264	6.9%
Pleasant Bay*	948	895	23.6%
Chatham Harbor*	481	481	12.7%
Total	**4,074 kg/yr**	**3,796 kg/yr**	**100.0%**
	(8,983 lb/yr)	(8,370 lb/yr)	

* These sub-watersheds account for 64% of total attenuated stormwater load

Nearly two-thirds of the impervious area attenuated nitrogen load comes from five sub-watersheds (Upper and Lower Muddy Creek, Ryder's Cove, Pleasant Bay and Chatham Harbor). (The Alliance is currently refining the estimates of natural attenuation in certain sub-watersheds.)

If 25% of the stormwater nitrogen load could be removed by MS4 activities, alone or with cost-effective enhancements, this would represent about 950 kg/yr of attenuated load or about 5.4% of the total load removal need of 17,700 kg/yr. To the extent that this removal is required of the towns under the MS4 program, and presumably will be accomplished regardless for the Watershed Permit, it only makes sense to gain credit and reduce the scope of other costly control measures.

An update of the 2006 MEP Technical Report was undertaken by UMass Dartmouth in 2021. The updated watershed load estimates include impervious area loads of 4,818 kg/yr (un-attenuated), an increase of about 18% over the 2006 estimate. Some of this increase is due to new development and some results from a change in how the impervious areas are determined. As refinement of that

MEP update continues, this current evaluation will use the stormwater loadings from the 2006 MEP report.

CRITERIA FOR DOCUMENTING NITROGEN CREDITS

If the towns are to seek formal credits for stormwater-based nitrogen removal activities against their obligations under the Watershed Permit, the following are needed:

- There should be a written procedure that stipulates how the credit will be determined, and all of the towns and DEP must agree to those procedures. (The 2018 Targeted Watershed Management Plan contains several appendices that spell out such procedure for other nitrogen removal techniques.)
- The data supporting the credit must include measurement of actual nitrogen removal, not just theoretical information or removals documented elsewhere. This is an important precept established by DEP.
- The time and expense requirements to generate and report the local information must be commensurate with the magnitude of the resulting credit, particularly in light of the availability of key town staff.

Given the need for actually measuring field parameters to gain a credit, this report sets forth a computational procedure that would eventually be updated and refined by field measurements. Literature values are used in this report for illustrative purposes to estimate the likely magnitude of credits, but those credits would not be formally achieved until field measurements confirm or adjust these calculations.

To help gauge the time requirement of town staff, two sample sub-watersheds were analyzed, based on data provided by the towns. The Meetinghouse Pond and Round Cove sub-watersheds were selected because they each lie in a single town (Orleans and Harwich, respectively) and the loads from these sub-watersheds are not subject to natural attenuation. Table 2 presents key data on these two sample sub-watersheds, compiled from the MEP report and from town sources. (Staffing constraints in Harwich precluded the development of more specific details in the Round Cove sub-watershed, and Table 2 presents just the MEP-based data for Round Cove to allow a high-level comparison with Meetinghouse Pond.)

If nitrogen removals are identified that are not easily supported by field measurements, they will not qualify as formal credits. Nonetheless, these removals are real and contribute to the reversal of water quality impairments. Such removals should be identified and reported and should be viewed as a contingency toward TMDL compliance and/or as part of the TMDL safety factor.

Table 2. Data on Sample Sub-Watersheds

Town	Meetinghouse Pond Orleans		Round Cove Harwich	
Data from MEP Technical Report, 2006				
Watershed area, acre	325		318	
Number of developed parcels	261		263	
Natural attenuation of N load, %	0		<1	
Nitrogen loads, kg/yr				
Impervious area load	193	9%	154	10%
Septic load	1,811	82%	1,157	75%
Fertilizer load	139	6%	175	11%
Natural area load	53	2%	54	4%
Total watershed load	2,196	100%	1,540	100%
Load removal need, kg/yr	1,876		1,209	
Impervious areas, acre				
Road	14.0	36%		
Roof	15.0	39%		
Driveways	9.8	25%		
Total	38.8	100%		
Data from Towns, 2020				
Roadway length, ft	19,500			
Average roadway width, ft	19.7			
Total roadway area, ac	8.82			
Portion of roadway that is paved, %	98.05			
Paved roadway area, ac	8.65			
Number of catch basins				
total	72			
with sumps	36			
Street sweeping frequency				
2004	annual			
2020	annual			
Catch basin cleaning frequency				
2004	annual			
2020	1 to 3 yr			
Leaf pick-up?	no			
Structural BMPs				
Existing in 2005				
Existing in 2020	6			
Planned post-2020	2			

REQUIREMENTS OF EPA MS4 PROGRAM

Most of the land in the four Pleasant Bay watershed towns is subject to the requirements of the MS4 program. Specific requirements are detailed in the Massachusetts General Permit, the current version of which was issued in April of 2016 and became effective in July of 2018. The General Permit was subsequently modified, with the modifications effective in January of 2021.

Each community is required to develop a Stormwater Management Plan (SWMP) which details the activities that will be implemented to meet the permit requirements.

The General Permit sets forth six Minimum Control Measures:

1. Public Education and Outreach
2. Public Involvement and Participation
3. Illicit Discharge Detection and Elimination
4. Construction Site Runoff Control
5. Post Construction Stormwater Management
6. Good Housekeeping and Pollution Prevention in Municipal Operations

It is Minimum Control Measure 6 that is the focus of this investigation.

Best Management Practices (BMPs) fall into two categories: structural and non-structural. Structural BMPs, such as rain gardens or gravel wetlands, can reduce the volume and peak flow rate of stormwater and can remove various contaminants. Non-structural BMPs, such as street sweeping and catch basin cleaning, are municipal activities and programs that manage stormwater without constructing physical facilities. Table 3 lists commonly used BMPs of both types.

Table 3. Common Best Management Practices (BMPs)

Structural BMPs	Non-Structural BMPs
Stormwater Ponds and Wetlands	Street Sweeping
Infiltration Practices	Catch Basin Cleaning
Filtering Practices	Leaf Collection Programs
Gravel Wetlands	BMP O&M Protocols
Bio-retention	New Septic O&M Programs
Rain Gardens	Illicit Discharge Detection/Elimination
Tree Filters	Municipal Regulations
Porous Pavements	Fertilizer Control Programs
Stormwater Conveyance	Pet Waste Pick-up Programs
Constructed Buffers	Outreach and Education

Appendix F of the General Permit addresses additional requirements ("enhanced BMPs") that apply to areas tributary to surface waters subject to approved TMDLs, such as Pleasant Bay. Measures are stipulated in Appendix F to ensure that nitrogen loads from MS4 stormwater do not increase. Enhanced BMPs are required in the areas of:

1. Public education and outreach
2. Stormwater management in new developments and redevelopment
3. Good housekeeping and pollution prevention in municipal operations
    - Minimum requirements for use of slow-release fertilizer
    - Procedures to manage grass clippings and leaf litter on municipal properties
    - Increased sweep sweeping frequency on public roads and parking areas.

Improved management of new development and redevelopment will help reduce future increases in stormwater nitrogen loads. The essence of this report is quantifying the nitrogen reductions related to municipal operations that may already have occurred or could be readily implemented.

It should be noted that current MS4 requirements do not include the municipal implementation of any structural BMPs for nitrogen removal, but merely the identification of potential municipal projects. However, future amendments to the MS4 general permit may do so.

BASIS FOR MEP ESTIMATE OF STORMWATER NITROGEN LOADS

The standard approach used in all of the MEP technical reports is to estimate nitrogen loads in impervious area runoff as the sum of the following:

- Nitrogen in street runoff: 40 inches of annual runoff at 1.5 mg/l nitrogen
- Nitrogen in driveway runoff: 40 inches of annual runoff at 1.5 mg/l nitrogen
- Nitrogen in roof runoff: 40 inches of annual runoff at 0.75 mg/l nitrogen

The concentration in roof runoff (0.75 mg/l) reflects the atmospheric deposition, while the difference between roof and road concentrations (0.75 mg/l) reflects the nitrogen picked up from the road surface from pet wastes, litter, leaves, runoff from adjacent areas, etc.

The MS4 General Permit expresses stormwater loads as "export rates", in pounds per year per acre of impervious surface (lb/yr/ac). The MEP calculations can be converted to export rates:

- Street and driveway runoff: 13.6 lb/yr/ac
- Roof runoff: 6.8 lb/yr/ac

For street runoff, EPA recommends an export rate of 14.1 lb/yr/ac, so the MEP calculations and the EPA performance estimates have nearly the same basis.

The two principal sources of nitrogen in stormwater are atmospheric deposition and the pick-up of nitrogen from solid material deposited on the street from various activities. If atmospheric deposition is approximately 60% soluble nitrogen forms (nitrate and ammonia), and the street pick-up is all in the particulate form, then a mass balance indicates that the stormwater runoff should be about 30% soluble forms and 70% particulate forms. This ratio is consistent with literature values.

From a management perspective, steps that remove solids from stormwater will address the 70% of the stormwater load that is in particulate form. Removal of the soluble nitrogen fraction generally requires contact with vegetated surfaces as are common in structural BMPs. EPA

performance curves that treat infiltration as "removal" overstate actual removals in the Cape Cod setting.

PUBLIC VS PRIVATE SOURCES OF NITROGEN IN STORMWATER

Two of the three components of impervious area runoff (roof and driveway sources) are under private control. It is only the road runoff component that can be directly reduced by municipal actions. The MEP data for the Meetinghouse Pond sub-watershed indicate that, for a hypothetical 10 acres of impervious surface, the total stormwater load would be about 110 lb/yr; see Table 4.

This analysis shows that 45% of the nitrogen in impervious area runoff comes from roadway surfaces and 55% is derived from private roofs and driveways. If a broad goal is to find a way to take credit for 25% removal of the overall stormwater nitrogen load, then the municipally-controlled portion must be reduced by about 55%. If the focus is just on controlling the solid fraction, then 80% of that fraction must be removed to reach this hypothetical 25% removal goal.

Table 4. Nitrogen Loads in Illustrative 10-acre Area

Source of Runoff	Area, ac	Nitrogen Conc, mg/l	Nitrogen load, lb/yr			Percentage
			Particulate	Soluble	Total	Distribution
Roofs	3.9	0.75	11	16	27	55%
Driveways	2.5	1.5	24	10	34	
Roads	3.6	1.5	34	15	49	45%
Total	10		69	41	110	100%

MEP-based loading rate for roads	13.6 lb/yr/ac (EPA: 14.1 lb/yr/ac)		
25% removal of total impervious load	25% of	110 lb/yr	= 27 lb/yr
Removal as % of total roadway load	27 out of	49 lb/yr	= 55%
Removal as % of particulate roadway load	27 out of	34 lb/yr	= 80%

NITROGEN REMOVAL AND THE WATERSHED PERMIT

EPA Region 1, in conjunction with the New Hampshire Stormwater Center, has developed a series of performance curves for many structural BMPs. The curves predict the volume of runoff that will be removed by the BMP, as well as the removal of key pollutants (generally nitrogen, phosphorus, and heavy metals such as zinc). Typical performance curves are illustrated in Figure 1.

It is widely understood that measurement of the nutrient-removal performance of BMPs is quite difficult. The volume of runoff intercepted by the BMP varies widely during a storm event, as does the pollutant removal. These factors dictate a very comprehensive sampling approach, which is impractical under most circumstances. Therefore, EPA and Massachusetts advocate the use of these performance curves instead of field measurements and sampling.

Under the Watershed Permit, DEP has determined that nitrogen credits can be granted only where sufficient field sampling and analysis document the degree of nitrogen removal that has occurred. If such documentation is not feasible using structural Best Management Practices, then the associated removal cannot be formally credited.

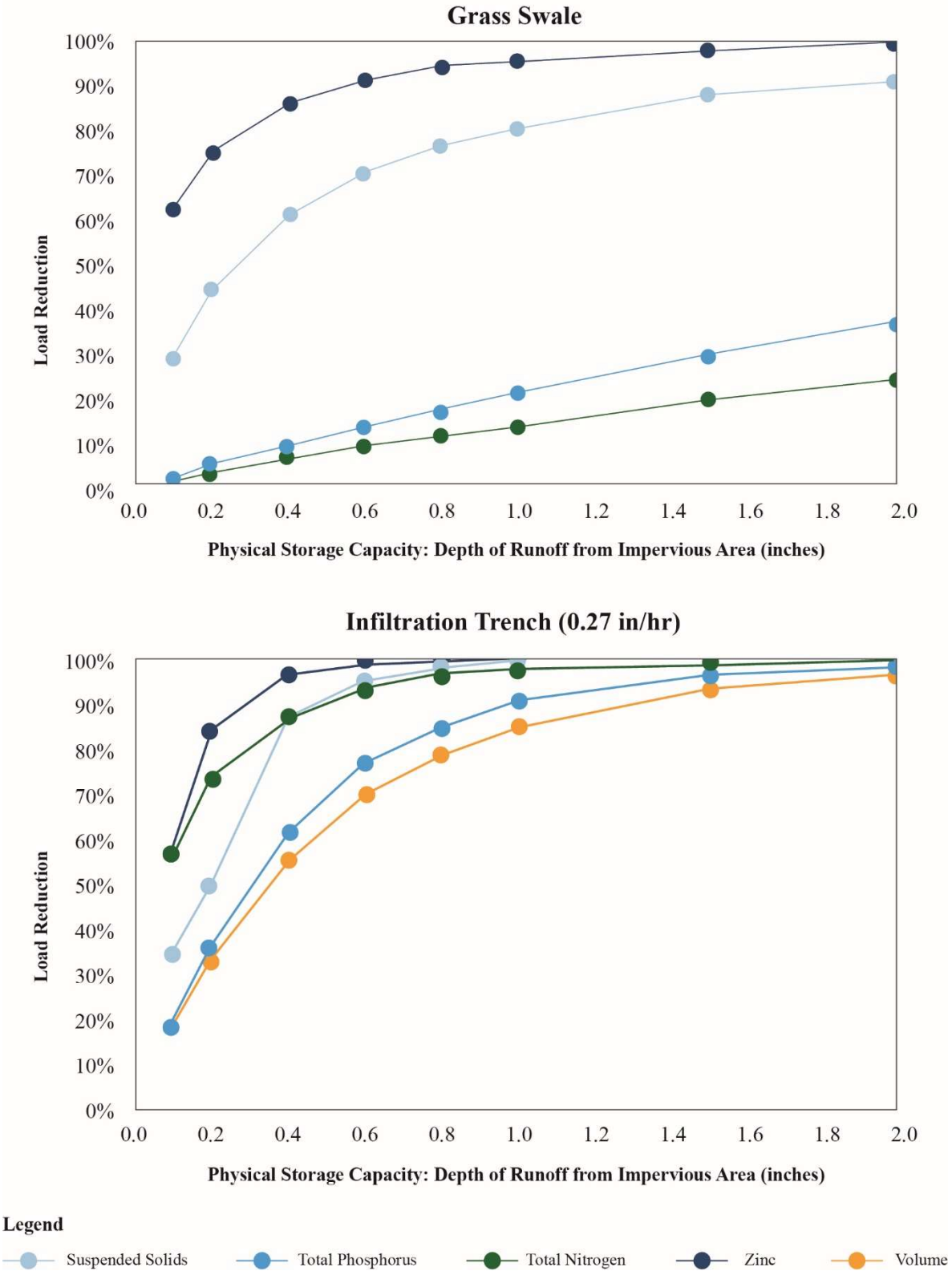
On the other hand, non-structural BMPs might be more easily documented if they rely on capturing the nitrogen tied up in the particulate fraction of the nitrogen load. Important examples are street sweeping and catch basin cleaning. If the collected solids are weighed and their nitrogen content is periodically determined, then field measurements of these activities might yield creditable nitrogen removals.

It is also recognized that sufficient land for structural BMPs is difficult to locate and/or purchase in this largely-developed watershed. Where structural BMPs have been installed or planned, they typically involve infiltration trenches or leaching catch basins. Such devices remove most of the particulate fraction of the runoff they receive but are largely ineffective in dealing with the soluble fraction. To remove the soluble fraction, some sort of biological or vegetated system is needed, but insufficient land often precludes this approach.

STORMWATER NITROGEN REMOVALS IN EXISTING STRUCTURAL BMPS

A review of stormwater management activities across Cape Cod found eleven stormwater management projects that use a variety of structural BMPs, including rain gardens, infiltration systems and gravel wetlands. The projects are located in Mashpee, Barnstable, Chatham, and Dennis. In three installations, nitrogen removal has been measured, and another two installations will be monitored in the near future. Where nitrogen removal has been measured, the percentage removals have ranged from an apparent negative removal to 45% removal. The attempts at estimating the removals clearly illustrate the highly variable influent volumes and concentrations and the diffuse nature of the discharge to groundwater. These local examples illustrate the difficulties that have led to the philosophy in the industry that EPA performance curves are a suitable indicator of performance, given the monitoring difficulties.

Figure 1. Sample BMP Performance Curves
Source: UNH Stormwater Center, 2019



BMP ACCOUNTING AND TRACKING TOOL

USEPA Region 1 has developed a spreadsheet-based tool to allow municipalities to account for, track and report nutrient load reductions from stormwater management activities. The tool (BMP Accounting and Tracking Tool, acronym BATT) is intended to standardize the accounting and tracking of MS4-related activities and can also aid in TMDL compliance reporting. This tool should be considered by all four of the watershed towns and adapted to the specific circumstances of the Watershed Permit. The adaptation would include adjustment factors for nutrient removals attributed to infiltration-based performance curves and for non-structural approaches.

MODEL FOR STORMWATER NITROGEN REMOVAL

This report presents a conceptual model for estimating removal of stormwater nitrogen in the Pleasant Bay watershed. Fundamental to the approach is the need to undertake field measurements to confirm or adjust the assumptions in this conceptual model.

Estimated nitrogen removal will consist of the following components

1. Removal of street solids through street sweeping
2. Removal of street solids through catch basin cleaning
3. Municipal leaf collection
4. Structural BMPs

For the first three measures, nitrogen credits will be determined through measurement of the volume or weight of solids collected (already required by MS4 permit) and the measurement of the nitrogen content of those solids. The performance of structural BMPs will not be confirmed with field measurements, but the estimated removals will be tracked as a contingency toward TMDL compliance.

Street sweeping

Based on literature studies (see Kalinowsky *et al*, Donner *et al* and TetraTech), street solids removal is estimated to be

- Sweeping once per year (spring) 6% of annual solids load
- Sweeping twice per year (spring and fall) 10%
- Sweeping three times per year 12%
- Sweeping monthly 15%

The recovered solids are estimated to be 0.2% nitrogen. If the street solids represent a nitrogen loading of 6.8 lb/ac/yr (see Basis of MEP estimate, above), the implied solids load is 2,800 lb/yr per curb-mile or 3,400 lb/yr per acre of paved roadway (compare Donner *et al* at 600 lb/curb-mile).

Catch basin cleaning

Each catch basin with a sump is assumed to remove 50% of the street solids in its tributary area if cleaned regularly.

Leaf pick-up

Based on literature reports (see Selbig), leaf pick-up is estimated to remove nitrogen as follows:

- Fall pick-up 0.6 lb/yr/ac
- Spring and fall pick-up 1.0 lb/yr/ac

Structural BMPs

Nitrogen removal is computed in accordance with the EPA performance curves, with an adjustment factor for infiltration. It is assumed that solids removed in the BMP represent 70% of the removal and 30% infiltrates to groundwater, in the absence of vegetation. In the absence of natural attenuation that might remove the infiltrated soluble nitrogen, it is just the particulate fraction that is removed from the watershed load, assuming regular maintenance, and the nitrogen removed is 70% of that predicted by the curves for infiltration facilities. The average nitrogen removal predicted for six structural BMPs in the Meetinghouse Pond sub-watershed is 4 lb/yr per installation using adjusted performance curves.

NITROGEN REMOVAL FOR VARIOUS MANAGEMENT SCENARIOS

The above computational approach was applied to four scenarios:

- Conditions that existed in 2005 (the basis for the MEP technical report)
- Current conditions (2020)
- A moderate increase in intensity of municipal operations
- A large increase in intensity of municipal operations.

The predicted nitrogen removals for the Meetinghouse Pond sub-watershed in Orleans are shown in Table 5.

2005 Conditions

According to the Town of Orleans, street sweeping and catch basin cleaning occurred annually and there were 4 structural BMPs in place. These BMPs were not explicitly accounted for the MEP study. Based on the factors listed above, the nitrogen removal from roadways in 2005 was approximately 27 lb/yr. This represents 14% of the roadway load and 6% of the overall impervious area load in this sub-watershed.

2020 Conditions

By 2020, annual street sweeping continued, there was less catch basin cleaning and 2 additional structural BMPs were in place. Based on the factors listed above, the estimated nitrogen removal from roadways in 2020 was approximately 33 lb/yr, with the additional structural BMPs more than offsetting the less-frequent catch basin cleaning. The estimated nitrogen removal represents 17% of the roadway load and 8% of the overall impervious area load in this sub-watershed.

Table 5. Comparison of Nitrogen Removal Scenarios for Meetinghouse Pond

	2005 Conditions		2020 Conditions		Scenario 1		Scenario 2	
Removal Mechanism	**Frequency**	**Removal %, lb/yr**	**Frequency**	**Removal %, lb/yr**	**Frequency**	**Removal %, lb/yr**	**Frequency**	**Removal %, lb/yr**
Street sweeping	annual	6%	annual	6%	semi annual	10%	monthly	15%
		6.1		**6.1**		**10.2**		**15.3**
Catch basin cleaning	annual	30%	biennial	15%	annual	30%	annual	30%
		5.1		**2.6**		**5.1**		**5.1**
Leaf pick-up	none	0	none	0	fall	0.6	spring & fall	1.0
		0		**0**		**9**		**15**
Structural BMPs	4	4	6	4	8	4	10	4
		16.0		**24.0**		**32.0**		**40.0**
Total Removals		**27.2**		**32.7**		**56.3**		**75.4**
Creditable toward TMDL		11.2		8.7		24.3		35.4
Contingency		16.0		24.0		32.0		40.0
Total, lb/yr		**27.2**		**32.7**		**56.3**		**75.4**
Total, lb/yr/ac		1.8		2.2		3.8		5.0
Total roadway load, lb/yr		190		190		190		190
Overall % removal		14%		17%		30%		40%
Total Impervious load		425		425		425		425
Overall % removal		6.4%		7.7%		13.2%		17.7%

Total street solids and N loading		**Catch Basin Data**		**Leaf pick-up**	
lb/yr/ac	3,400	CB tributary area, ac	5	Area, ac	15
ac	15	Max. CB removal	50%	N removal, lb/ac/yr	
lb/yr	51,000	Max. lb/yr captured	17	fall	0.6
N content	0.20%	**Structural BMPs**		spring/fall	1.0
N load, lb/yr	102	avg lb/yr rem.	4		

Comparison of the calculations for 2005 and 2020 conditions appears to justify a reduction in stormwater nitrogen load of 6 lb/yr since the 2006 MEP report. However, if removals through structural BMPs cannot be formally credited, then this small increase in removal can only be viewed as a contingency against TMDL compliance, or as part of the TMDL safety factor.

Scenario 1—Moderate Increase in Municipal Operations

This scenario was formulated to estimate the nitrogen removal from a moderate increase in both non-structural and structural measures. Street sweeping would be increased to twice per year and a fall leaf pickup would occur. Two already-planned structural BMPs would be constructed. In this scenario, the nitrogen removal would increase to 56 lb/yr, a 70% increase over current conditions. This represents 30% of the roadway load and 13% of the overall impervious area load in this sub-watershed.

Scenario 2—Significant Increase in Municipal Operations

This scenario was formulated to estimate the nitrogen removal from a much more aggressive increase in both non-structural and structural measures. Street sweeping would be done monthly, leaf pick-up would occur both spring and fall, and two additional structural BMPs would be constructed. In this scenario, the nitrogen removal would increase to 75 lb/yr, a 130% increase over current conditions. This represents 30% of the roadway load and 18% of the overall impervious area load in this sub-watershed.

Overall

For all of the conditions and scenarios in Table 5, comparisons are shown against the total road runoff load of 190 lb/yr and the total impervious area runoff (roads, drives and roof) of 425 lb/yr.

Table 5 also segments the estimated removals into two categories: the portion that can be verified with field measurements (street sweeping, catch basin cleaning and leaf pick-up) and the removals that must be estimated from EPA performance curves or similar theoretical approaches. In each scenario, well less than half of the projected removal can be field-verified.

To put these removal estimates in perspective, it is helpful to consider nitrogen removal by sewering. Eliminating one septic system, by connection to a municipal sewer (with treatment and disposal outside the watershed), typically removes about 12 lb/yr of nitrogen load. The removals in the 2005 and 2020 conditions are thus equivalent to sewering two or three homes. Enhanced stormwater management, as illustrated by Scenarios 1 and 2, are roughly equivalent to the nitrogen removal from 5 to 6 homes.

GENERAL ALLOWANCES VERSUS SPECIFIC ACTIVITIES

In the Cape Cod Commission's 208 Water Quality Management Plan, the Commission suggested that individual town plans could include across-the-board allowances for residential fertilizer control and stormwater management because the nitrogen removal capabilities of those activities are difficult to quantify. The Commission suggested that towns take a 25% credit for fertilizer controls and a 25% credit for stormwater management.

When the Pleasant Bay TWMP was developed, the four towns agreed that each town could take a 25% credit for residential fertilizer controls once the town enacted regulations or bylaws with appropriate measures. Recent annual reports under the Watershed Permit have included credits in this category of 120 to 250 kg/yr, with a four-town total of 809 kg/yr. This 25% credit against residential fertilizer loading represents 4.6% of the total load removal need of 17,700 kg/yr.

The four towns also discussed the possibility of taking a similar 25% credit against the MEP-estimated stormwater load, but decided not to do so without information on the nature and extent of stormwater controls that the towns have implemented or might adopt. If an across-the-board 25% credit had been taken, it would have been for 1,018 kg/yr of un-attenuated load or 949 kg/yr of attenuated load. The aggregate amount would be 5.4% of the total load removal need, and thus is roughly equivalent to the fertilizer credit that has been taken.

This study addresses the nitrogen load removals that have occurred in one sample sub-watershed or could occur with an enhanced stormwater program. If the results of the Meetinghouse Pond example are applicable watershed wide, then this study's findings can be compared to the hypothetical 25% allowance suggested by the Commission; see Table 6. Current activities in the Meetinghouse Pond sub-watershed are removing 2% to 3% of the MEP-estimated stormwater loading there, based on street sweeping and catch basin cleaning practices that can be supported by field measurements. These percentages rise to 6% to 8% of the total watershed load if structural BMP measures are credited using performance curves. These relatively low removal percentages seem to support the Alliance's prior decision not to use the Commission-recommended 25% allowance.

Nitrogen removals from activities that can be field verified would rise to 6 to 8% of the total stormwater load if current programs are enhanced. If performance-curve-estimated activities are also credited, then as much as 18% of the total stormwater load would be removed.

Table 6. Nitrogen Removals as a Percentage of the Total MEP Stormwater Load

Scenario	Measured Removal (Field Data)	Estimated Removal (Perform. Curves)	Total Removals
2005 Conditions	2.6%	3.8%	6.4%
2020 Conditions	2.0%	5.7%	7.7%
Scenario 1: Moderately Enhanced Program	5.7%	7.5%	13.2%
Scenario 2: Significantly Enhanced Program	8.3%	9.4%	17.7%
Methods	Non-Structural BMPs	Structural BMPs	Combination

In agreeing to include the Commission's recommended 25% allowance for nitrogen removal via residential fertilizer controls, the four towns recognized that the actual removals are nearly impossible to measure, and that the achievement of target nitrogen concentrations in the water column is needed regardless of the actual contribution of those fertilizer controls to the town's overall success. Use of an across-the-board percentage removals for stormwater management is also possible, with the same caveat about uncertainty. The towns must recognize that uncertainty and have a flexible program that can be adjusted based on actual water quality improvements.

CONCLUSIONS

This report quantifies the actual stormwater nitrogen removals that have occurred in the Meetinghouse Pond sub-watershed and extrapolates those estimates to more intensive stormwater management scenarios. If this sub-watershed is representative of watershed-wide conditions, it can be concluded that current management and potential more aggressive activities are unlikely to result in more than 18% removal of the total impervious area nitrogen load estimated in the 2006 MEP report that is the basis of the TMDLs.

Specific findings of this report include:

1. The MEP reports indicate that about 9% of the total nitrogen load to Pleasant Bay comes from impervious area runoff.
2. About 55% of the total stormwater nitrogen load originates from private sources (roofs and driveways) and 45% is associated with (largely) public roadways. Thus, less than one-half of the stormwater nitrogen load can be affected by municipal actions.
3. Based on data from the Meetinghouse Pond sub-watershed, current municipal stormwater management activities are removing about 6% to 8% of the overall nitrogen load from impervious surfaces.
4. Stormwater Best Management Practices in the watershed rely heavily on infiltration of stormwater. EPA BMP performance curves overstate the associated nitrogen removal because the infiltrated stormwater nitrogen still reaches the embayments on Cape Cod. Even if these infiltration-based techniques capture all of the stormwater solids, and are cleaned regularly, they will actually remove (from the watershed) only 70% of that predicted by the EPA curves.
5. For the Meetinghouse Pond case study, more aggressive municipal stormwater management activities might increase the nitrogen removal to 13% to 18% of the total stormwater load (from the current 6% to 8%). The increase would require more frequent street sweeping and catch basin cleaning and the implementation of a leaf collection program.
6. DEP has taken the stance that nitrogen removal under the Watershed Permit must be supported by field measurement and cannot rely solely on published data or experiences elsewhere. If that philosophy continues to apply, only 30% to 50% of the estimated nitrogen removal in Meetinghouse Pond sub-watershed can be claimed as a credit. In the scenario involving aggressive expansion of management activities in the Meetinghouse Pond area, the creditable removals would be 8% of the total stormwater load, compared to the total removal of 18%.

7. Through street sweeping and catch basin cleaning, the towns can measure the weight of street solids that are removed. Regular measurement of the nitrogen content of those solids will allow the computation of the weight of nitrogen removed, and form the basis for a removal credit.
8. For this sub-watershed, there appears to be no MS4-related nitrogen removals between 2005 and 2020 that can be credited against the TMDL.

This report does not attempt to estimate the added costs to the towns to strengthen their stormwater management activities on town roads. If the towns elect to do so, they should be able to take small credits for the resulting nitrogen removals. Each town must decide if the costs (including equipment costs and staff time) are commensurate with the removals. Since some of these non-structural activities are required under the MS4 permit, the additional costs should be small. However, the more aggressive option described above will carry significant additional costs.

This report focuses on nitrogen removal from streets via stormwater management activities. There are many other benefits of stormwater management, such as flow reduction and the removal of sediment, phosphorus, pathogen, and heavy metals. In many cases, the combined benefits of these activities are likely to be much more beneficial than just the nitrogen removal or TMDL compliance aspects.

NEXT STEPS

The following actions are recommended:

1. The towns should continue to measure and report the volume or weight of street solids collected from street sweeping and catch basin cleaning, and report (in their annual MS4 reports) both the total amount and the amount recovered from Pleasant Bay sub-watersheds.
2. A program should be developed to routinely measure the nitrogen content of recovered street solids. Routine measurements (perhaps every tenth load) should be compiled to serve as a baseline to later less-frequent measurements. The Pleasant Bay Alliance could coordinate this effort.
3. Data from the towns on nitrogen removals from stormwater should be reported to the Pleasant Bay Alliance for inclusion in its annual reports under the Watershed Permit.
4. The Towns should investigate the costs of municipal leaf removal and weigh the costs against the potential nitrogen removal credits.
5. Towns, with Pleasant Bay Alliance assistance, should explore the use of the EPA BMP Accounting and Tracking Tool (BATT) to organize nitrogen removal data and to formalize other stormwater management information.
6. The towns should review their stormwater bylaws to ensure that stormwater nitrogen control in development and redevelopment projects is accounted for with adjusted BMP performance curves as suggested in this report.
7. The approach used in this report to estimate stormwater nitrogen removal could be adapted to estimating stormwater phosphorus removal in the watersheds to freshwater ponds.

REFERENCES

The following literature was used in the preparation of this report:

1. Kalinowsky, *et al;* User Support Manual: Estimating Nutrient Removal by Enhanced Street Sweeping; Minnesota Pollution Control Agency; 2014.
2. Donner, *et al*; Recommendation of the Expert Panel to Define Removal Rates for Street and Storm Drain Cleaning Practices; Chesapeake Bay Project; 2016.
3. Tetra Tech; Memo on Street Cleaning Pollutant Reductions and Crediting; 2020.
4. Selbig; Evaluation of Leaf Removal as a Means to Reduce Nutrient Concentrations and Loads in Urban Stormwater; *Science of the Total Environment*; 2016.
5. Street Sweeping for Trees; Minnesota Stormwater Manual.
6. BMP Accounting and Tracking Tool (BATT): User's Manual; TetraTech for EPA Region 1; June 2016.

ACKNOWLEDGMENTS

This project was funded by a 2020 Watershed Grant from the Southeast New England Program (SNEP). SNEP is an initiative of the US Environmental Protection Agency and is administered by Restore America's Estuaries. Significant support to this study was provided by the Pleasant Bay Alliance's Watershed Work Group and by technical consultants to the watershed towns.

ATTACHMENT S

EASTHAM MEMORANDUM OF UNDERSTANDING

(June 8, 2023)
Memorandum of Understanding
Between
The Town of Orleans and Town of Eastham
Collaboration for DEP Watershed Permit

This Memorandum of Understanding (hereinafter, "MOU") is entered into this___day of _____2023, by and between the Towns of Orleans and Eastham (hereinafter, "the Towns"), both municipal corporations located in Barnstable County, Massachusetts, acting through their Select Boards. The purpose of this MOU is to continue a process for coordination between the Towns in pursuing joint Watershed Management Permit(s) from the MA Department of Environmental Protection (hereinafter, "DEP").

WITNESSETH

WHEREAS, the Towns recognize the need to provide improved wastewater and nitrogen management by remediating the current nitrogen loading to coastal estuaries as identified in the Massachusetts Estuaries Project (MEP) reports; and

WHEREAS, both Towns are currently working with consultants on implementing town-specific wastewater management plans; and

WHEREAS, the Towns share responsibility for both the Nauset Harbor and Rock Harbor Embayment Systems; and

WHEREAS, the Towns wish to collaborate and to apply for a joint DEP Watershed Management Permit for their shared waterbodies as required; and

NOW THEREFORE, in consideration of the foregoing, the Towns agree as follows:

1. The Towns agree to continue to work cooperatively with one another towards addressing the proposed goals through regular meetings, exchange of information and technical data, and if needed, joint contracts for services.

2. More specifically, the Towns agree to pursue the State of Massachusetts DEP joint Watershed Management Permit(s) (hereinafter, "the Permits") for the Nauset Harbor and Rock Harbor Embayment Systems.

3. As part of the process, the Towns will collect any outstanding data necessary to apply for, and obtain, the Permits. This may include an updated Land Use Plan, continued collection of sampling data, and pursuing scientific data to establish Total Maximum Daily Loads (TMDLs).

4. The Towns agree to share any information or report communications from regulatory agencies relating to the watersheds.

5. The Towns agree that subject to funding availability, the Towns will equally share the cost of necessary studies or plans, or any other costs associated with the permitting process.

6. All contracts with consultants shall require the applicants to have written approval from the Towns.

7. All permit applications shall require the applicants to include written approval from the Towns prior to submittal of said application to the subject agency(ies).

8. This Agreement and the obligations of the Towns hereunder shall be subject to the availability of funding and staffing, and nothing contained herein shall be construed as binding the Towns to expend any sum in excess of appropriations made or administratively allocated for the purpose of this Agreement, or to involve the Towns in any contract or other obligation for the further expenditure of money in excess of such appropriations or allocations.

9. This Agreement shall remain in effect through the application, review, and issuance of the Permit(s).

10. This Agreement may be terminated by either party by providing 45 days written notice to the other party.

11. This Agreement may be amended by either party by providing written notice of the proposed amendment(s). The other party shall have up to 45 days to accept, counter, or reject the proposed amendment(s).

12. This Agreement shall be executed by each party's Select Board Chair. Subsequently, each party, independent of the other, may appoint different or additional signatories, representatives, and/or governing bodies for the purposes, functions, roles, and responsibilities created by this Agreement.

IN WITNESS WHEREOF, the parties have caused this instrument to be executed by their respective duly authorized representatives on the day and year indicated above.

Michael A. Herman — June 7, 2023

Michael A. Herman — *Date*
Orleans Select Board Chair

_____ — _____

Jamie Demetri — *Date*
Eastham Select Board Chair

ATTACHMENT T

REPORT ON NITROGEN TRADING OPPORTUNITIES AMONG WATERSHED TOWNS

PLEASANT BAY ALLIANCE

Report on Nitrogen Trading Opportunities Among Watershed Towns

Task 2 of Regional Watershed Permit Implementation Project funded by EPA Southeast New England Program (SNEP)



Prepared by:

WRIGHT-PIERCE
Engineering a Better Environment

Wright-Pierce
600 Federal Street
Andover, MA 01810
September 24, 2021

PLEASANT BAY ALLIANCE

Report on Nitrogen Trading Opportunities Among Watershed Towns

Task 2 of Regional Watershed Permit Implementation Project funded by EPA Southeast New England Program (SNEP)

September 24, 2021

SUMMARY

The four towns in the Pleasant Bay watershed (Brewster, Chatham, Harwich, and Orleans) have committed to removing nitrogen loads from their portions of the watershed to reduce this contaminant's significant influence on water quality in the Bay. The towns' nitrogen removal commitments are included in the 2018 Watershed Permit issued by MassDEP.

Each town has developed a plan for meeting its nitrogen removal commitments and those plans are being fine-tuned as more is learned about the expected performance and costs of certain technologies and as the Bay's assimilative capacity is better understood. The towns' plans include seven projects involving five technologies that have a range of costs:

- Low cost—golf course fertilizer management and shellfish harvesting
- Moderate cost—public sewers
- Higher cost—on-site denitrification and permeable reactive barriers

It may be possible and economical for one town to remove more nitrogen than called for in the Watershed Permit in exchange for payment by another town whose responsibility would be commensurately less. This concept is called "nitrogen credit trading", or simply "nitrogen trading". By increasing the use of the lower-cost technologies and reducing the use of the more expensive approaches, trading could reduce the overall cost for nitrogen removal. This report explores the nitrogen trading concept as it applies to Pleasant Bay. Key findings are:

Regional and National Experience

Contaminant credit trading is relatively new but has become widespread across the country. One of the most successful nitrogen trading systems is in place in Connecticut as part of the program to protect Long Island Sound. MassDEP and the Cape Cod Commission each have nitrogen offset policies that represent a form of nitrogen trading.

Unit Costs for Town Projects

Analysis of town cost data indicates that public sewers proposed in Chatham, Harwich, and Orleans cost about $320 to $430 per pound of nitrogen removed, considering capital costs for new facilities and long-term operation and maintenance costs. Unit costs for golf course fertilizer controls and shellfish harvesting are significantly less ($10 to $150 per pound), but these projects are of limited capacity. The most expensive technologies are on-site denitrification and permeable reactive barriers that carry costs of $700 to $750 per pound.

Potential Trading Scenarios

Three trading scenarios have been identified and evaluated. These scenarios involve Brewster, Harwich, and Orleans wherein the Seller would expand its nitrogen removal project on behalf of the Buyer, who would save money by reducing its more expensive plan. Some of the savings to the Buyer would serve as an incentive to the Seller to participate. The transfers of nitrogen removal responsibility in these three illustrative scenarios would involve about 10% of the overall removal need Bay-wide.

Potential Cost Savings

The three illustrative scenarios offer cost savings totaling over $670,000 per year, equivalent to an up-front cost of about $11 million. The savings to the Buyers represent about 14% of the buyers' expected costs for the more expensive technologies.

Considerations Related to Trading

Numerous issues related to nitrogen trading are discussed, including

- Coordination with the Watershed Permit
- Provisions of intermunicipal agreements
- Forms of payment
- Grants and loans
- Impacts of new development in the watershed and changes in the Bay's assimilative capacity.

Schedule

If one or more of these trading opportunities is implemented, detailed evaluation and negotiations will be required. Changes in the Watershed Permit would be needed and could be accomplished by the permit review scheduled for 2028.

INTRODUCTION

Pleasant Bay is a 6,200-acre estuary, the largest on Cape Cod. The Bay's watershed is 11,800 acres in extent and spans the towns of Brewster, Chatham, Harwich, and Orleans.

Extensive studies over the last 15 years have documented a decline in water quality in the Bay and those studies have quantified the nitrogen loading from the four towns that have contributed to that decline. The principal components of the current nitrogen load are on-site septic systems (75%), lawn and golf course fertilization (16%) and stormwater runoff (9%).

Evaluation of many Cape Cod embayments has been accomplished under the Massachusetts Estuaries Project (MEP). Studies in 2006 and 2010 by the School of Marine Science and Technology (SMAST) at UMass-Dartmouth have estimated the "threshold loads" of nitrogen (the loads that just maintain receiving water quality) for 19 sub-embayments that comprise Pleasant Bay. The four towns in the watershed have agreed that each town's responsibility to meet these thresholds should be proportional to each town's current loading to the Bay.

When this allocation concept is applied to loadings and thresholds in the 19 sub-embayments, the responsibilities are as follows:

- Brewster 2,262 kg/yr (12.8%)
- Chatham 4,076 kg/yr (23.0%)
- Harwich 4,399 kg/yr (24.8%)
- Orleans 6,980 kg/yr (39.4%)
- Total 17,717 kg/yr (100% of total responsibility)

In August 2018, the four towns signed a MassDEP Watershed Permit that binds each town to its share of removal responsibility and sets forth milestones for accomplishing those removals in four 5-year time blocks. The third year of the first 5-year block has just been completed.

It may be possible and economical for one town to remove more nitrogen than called for in the Watershed Permit in exchange for payment by another town whose responsibility would be commensurately less. This concept is called "nitrogen credit trading", or simply "nitrogen trading". If possible and economical, trading could reduce the overall cost for nitrogen removal. This report explores the nitrogen trading concept as it applies to Pleasant Bay.

NATIONAL AND REGIONAL EXPERIENCE WITH NUTRIENT TRADING

Pollutant trading programs have been used across the United States and cover such diverse issues as atmospheric emissions of air pollutants, discharges of greenhouse gases, and point- and non-point sources of nitrogen and phosphorus. Prominent water-quality-related programs exist in the Chesapeake Bay region (focusing on phosphorus loading from Pennsylvania, Virginia, and Maryland), the Miami River watershed (Ohio), North Carolina (dealing with phosphorus and nitrogen from point and non-point sources), Oregon (focusing on point sources) and Connecticut (related to Long Island Sound--see below).

These programs are either two-party arrangements or involve a third party, such as a "nutrient bank" or "carbon bank". Considering the complexity of three-party arrangements, especially the need to create the bank, it is recommended that Pleasant Bay towns conduct two-party trading between the Buyer and the Seller.

Connecticut DEEP Program for Long Island Sound

The Connecticut Department of Energy and Environmental Protection (DEEP) prepared, and EPA approved, a nitrogen-based TMDL for Long Island Sound in 2001. The TMDL establishes the need to reduce the nitrogen loads to the Sound by 58% overall, or by 63% if reductions are achieved only on point sources (*i.e.*, the 79 wastewater treatment plants in the watershed). CT DEEP created a Nitrogen Credit Exchange, and all wastewater treatment facilities operate under a Nitrogen General Permit.

Equivalency Factors (trading ratios) are set by a HydroQual model; the factors range from 1.00 (near the anoxic zone on the west end of the Sound) down to 0.14 to 0.16 (in northeastern Connecticut).

Early in the program, the Nitrogen Credit Exchange (the "bank") set the trading price at about $2.00 per pound and in recent years the price has been about $6.00 per pound. (These prices seem very low by Cape Cod standards. In the Long Island Sound program, buyers and sellers all own wastewater treatment facilities and established sewer systems, and the trading prices relate to end-of-pipe modifications that are much less expensive than the full collection-treatment-disposal systems needed on Cape Cod.)

CT DEEP believes that this is the most complex and extensive trading program for water quality parameters in the US. Because it involves the buyer, the seller and the Nitrogen Credit Exchange, this is considered a three-party trading system.

Since the initiation of this program, wastewater treatment plans have achieved 88% of the targeted removal and atmospheric deposition has dropped by 26%. The TMDL was achieved in 2014, but anoxic conditions persist in the western Sound. Accordingly, DEEP has embarked on its "second generation" plan to include non-point sources of nitrogen.

In recent years, CT DEEP has found that there is more money going out to sellers than there is money coming in from buyers. To make the program sustainable, there is now a buy/sell differential. For 2018, buyers pay $6.61 per pound and sellers receive $2.59 per pound.

Massachusetts DEP No-Net-Nitrogen Policy

MassDEP requires that a permitee for a new groundwater discharge in a nitrogen sensitive watershed must have a plan to remove as much existing nitrogen load as the new discharge would create. The permittee's "nitrogen offset" must occur in the same watershed as the proposed new discharge, and the offset must be in place before the new discharge can begin. In essence, this policy creates a nitrogen credit trade between a Buyer (the new permittee, generally a developer) and another party (the Seller) who institutes a reduction in current nitrogen load that is paid for by the Buyer.

There are no DEP-imposed cost considerations; the developer must find and pay fully for whatever offset makes sense in the given circumstances.

Examples of projects that have been permitted under this DEP policy are:

- Cotuit Meadows in Barnstable: the developer oversized the private wastewater treatment facility to be able to receive wastewater flow from an existing nearby nursing home (located in Mashpee).
- Canalside Commons in Bourne: the permitted flow from an existing abandoned grocery store was used to provide part of an offset for a mixed-use development.

This is an example of a two-party trading system.

Cape Cod Commission Nitrogen Offset Policy

Under the 2019 *Regional Policy Plan* and the *Water Resources Technical Bulletin*, the Commission can require proponents of a Development of Regional Impact to completely offset the new nitrogen load from that project if it is located in a nitrogen-sensitive watershed. The Commission can allow a nitrogen offset fee in lieu of the actual offset. The *Bulletin* allows a developer to pay the offset for projects in certain "placetypes" located in nitrogen-sensitive watersheds, where development is being encouraged, and where sewer systems are planned.

The load to be offset is computed based on expected actual wastewater flows, 26.25 mg/l effluent from on-site treatment and disposal, and allowances for non-wastewater loads (e.g., lawn fertilization and stormwater disposal).

The one-time fee paid to the Commission can be as much as $8,290 per annual kilogram. This is based on data from the 2010 Barnstable County Cost Report and assumes the developer is responsible for capital costs and 20 years of O&M costs. The fee is equivalent to $230 per pound, applied to all pounds expected to be discharged over 20 years.

Monetary offsets are held by the Commission and are made available to the municipality where the project is located for use in planning activities or for projects related to nutrient management.

This is an example of a trading program focused on "new" nitrogen load (load that did not exist at the time of the 2006 MEP study). It is in essence a three-party program: the developer, the Commission, and the municipality.

CURRENT TOWN PROGRAMS FOR NITROGEN MANAGEMENT

Each of the four Pleasant Bay watershed towns has prepared a comprehensive wastewater management plan, or equivalent, to set forth the technologies, sites, and costs for its intended nitrogen control plan. Since the publication of these plans, the towns have proceeded to fine-tune their intentions based on evolving information on the capabilities of various removal approaches. The current mix of technologies proposed to be implemented is summarized in Table 1.

About 60% of the planned nitrogen removal would be accomplished through traditional means, primarily public sewering in Chatham, Harwich, and Orleans. Sewering and fertilizer reduction at golf courses are considered traditional technologies, while fertigation, on-site denitrification, permeable reactive barriers (PRBs) and shellfish harvesting are considered non-traditional. MassDEP has required that towns using non-traditional approaches must have a traditional-technology-based contingency plan to be implemented if the non-traditional technologies prove ineffective. (This requirement must be considered if nitrogen trading scenarios include both traditional and non-traditional approaches.)

Chatham has agreed to accomplish its share of nitrogen removal under the Watershed Permit. Further, the town's plan is to provide sewers to all Chatham developed properties, and that will result in a significant "over-removal" compared to strict TMDL compliance.

Table 1. Nitrogen Load Removal Commitments by Town and by Technology

	Nitrogen Load Removal Commitment, kg/yr				
Technology	**Brewster**	**Chatham**	**Harwich**	**Orleans**	**Total**
Residential fertilizer controls	121	247	200	241	809
Golf course fertilizer controls	930				930
Golf course fertigation	230				230
On-site denitrification	981				981
Public sewers		3,829	4,199	2,014	10,042
Permeable reactive barriers				2115	2,115
Shellfish harvesting				300	300
Not yet identified				2310	2,310
Total	**2,262**	**4,076**	**4,399**	**6,980**	**17,717**
Subtotal--traditional	930	3,829	4,199	2,014	10,972
Subtotal--non-traditional	1,332	247	200	4,966	6,745

Removal commitments are as stated in the Targeted Watershed Management Plan and Watershed Permit. Recent modeling by SMAST indicates that better estimates of attenuation may impact removal responsibilities in Brewster, Chatham and Harwich.

Based on data that was used to support the Watershed Permit, Chatham's approach will remove 13,059 kg/yr from Pleasant Bay sub-watersheds, about three times its 4,076 kg/yr commitment under the Watershed permit.

On the other hand, Orleans has committed to 6,980 kg/yr of nitrogen removal but has not yet identified projects to remove all of that obligation. As shown on Table 1, there is still 2,310 kg/yr in nitrogen removal to be addressed, about one-third of the town's obligation.

Considering these deviations from the removal requirements, the aggregate load removal that is now planned is about 24,500 kg/yr, nearly 40% higher than the 17,717 kg/yr requirement.

While the aggregate amount is large, there would be several sub-watersheds that would not meet their threshold loads.

The original MEP modeling conducted in 2006 has recently been updated to address changes in watershed loads, attenuation, and hydrodynamics. This new information indicates that the towns' relative responsibilities may have changed.

ESTIMATED COSTS FOR TOWN-SELECTED TECHNOLOGIES

The costs of each selected technology or project will vary depending on the nature of the technology, local conditions, site availability, economies of scale and many other factors. Costs typically include the initial expenses to design, purchase, install or set up the technology/approach (the capital cost) and the on-going costs for operation, maintenance, equipment replacement and monitoring (the O&M cost).

Wright-Pierce acquired cost data from the towns and their consultants, and reviewed and adjusted those data for consistency and inflation. O&M costs were combined with debt service on the capital cost (at 2%, 20 years) to arrive at the equivalent annual cost. The amount of annual nitrogen removal effected by each technology was also estimated using a consistent set of assumptions. By combining the equivalent annual cost (in dollars per year) with the nitrogen removal (in kilograms per year) a "unit cost" can be derived in terms of dollars per kilogram (or converted to dollars per pound).

The results of this cost analysis are summarized in Table 2, which shows the estimated cost per kilogram (and cost per pound) for all five of the selected technologies in seven projects. This information is also shown graphically in Figure 1.

Figure 1. Pleasant Bay Unit Costs for Nitrogen Removal Technologies

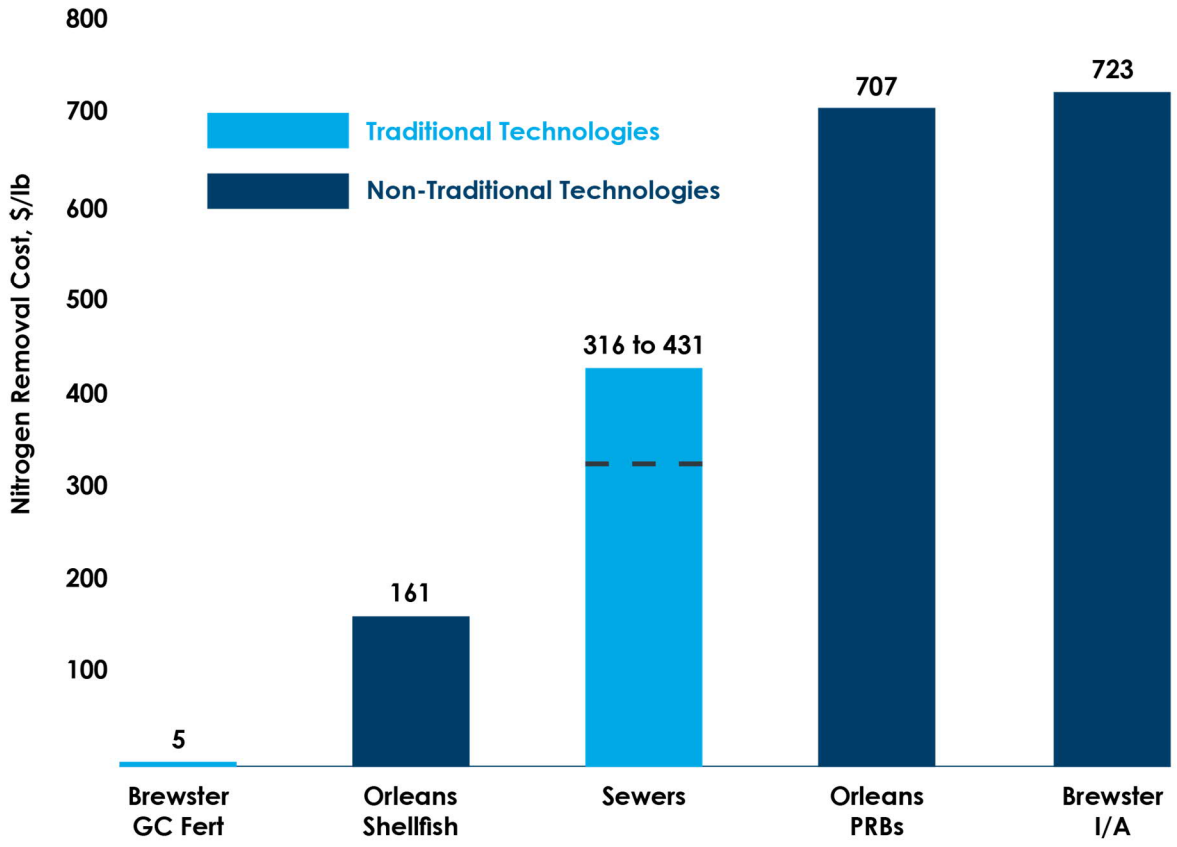


Table 2. Nitrogen Load Removal Costs by Technology and by Town

	Nitrogen Removal Costs, $/kg ($/lb)				
Technology	**Brewster**	**Chatham**	**Harwich**	**Orleans**	**Average**
Golf Course fertilizer controls and fertigation	10 **5**				10 **5**
On-site denitrification	1,595 **723**				1,595 **723**
Public sewers		734 **333**	698 **316**	950 **431**	736 **333**
Permeable reactive barriers				1,559 **707**	1,560 **707**
Shellfish harvesting				356 **161**	356 **161**
Overall	**736** **334**	**734** **333**	**698** **316**	**1,161** **526**	**835** **379**

Capital costs, $M	10.9	152.6	61.8	69.0	294
O&M costs, $M/yr	0.76	1.54	1.02	2.56	5.88
Equivalent Annual Cost, $M/yr	1.58	10.87	4.80	6.77	24.0

Cost data were provided by Towns and their consultants and adjusted by Wright-Pierce for consistency (ENR Cost Index of 11,630--early 2021)
Unit costs reflect the specific circumstances in each town and may not be applicable elsewhere
Each technology has a different level of reliability, scalability and resistance to environmental factors

The unit costs fall into three groups:

- Low Golf course fertilizer controls, shellfish harvesting ($10 to $150/lb)
- Medium Public sewers ($320 to $430/lb)
- High PRBs and on-site denitrification ($700 to $750/lb)

Combining the total Bay-wide cost with the total removal by all four towns results in an aggregate cost of about $380 per pound. Aggregate unit costs are in the range of $310 to $340 per pound in Brewster, Chatham, and Harwich and about $530 per pound in Orleans.

The projects reported in Table 1 represent a $300-million investment (before grants) watershed-wide and entail about $6 million in total annual O&M costs. The expenditures translate to an equivalent annual cost of $24 million with the standard SRF financing terms (2%) and $20 million with enhanced (zero percent) financing. (These watershed-wide costs do not include the costs for the 2,310 kg/yr "shortfall" in the Orleans program or any costs that may be related to changes in the Brewster program related to new attenuation estimates.)

Enhanced SRF financing and other grant programs reduce these unit costs. Compared to 2% financing, zero percent loans reduce the unit costs by 14 to 16% for sewering projects and by 4% to 9% for the more O&M-intensive non-traditional technologies. Chatham received sewer funding from Rural Development program which further reduced its unit costs by about 7%.

(It should be noted that the costs reported herein for a given technology reflect its use in very specific circumstances that may not apply elsewhere. Further, towns have selected technologies recognizing that each is different with respect to reliability, scalability, ability to withstand extreme natural conditions, etc. Costs are not the only factor that towns have considered.

EQUIVALENCY FACTORS

With nitrogen trading, one town would remove more than its share of nitrogen and the other town removes less than its share. If that trade occurs in the same sub-watershed, then the two load removals are equivalent and would have an Equivalency Factor of 1.0. If the trade involves removals in different sub-watersheds, then the town load removals may not be equivalent (Equivalency Factor < 1.0). For example, if Chatham were to remove 100 kg/yr in the Chatham Harbor (far southern) sub-watershed on behalf of Orleans, it might be equivalent to Orleans removing, say, 20 kg/yr in the Pochet (far northern) sub-watershed (Equivalency Factor of 0.2). The more distant the trade, the less likely that the full economy of the trade will be achieved.

Natural attenuation also factors into equivalency. Technologies applied upgradient of natural attenuation sources have a lower cost per kilogram of <u>un-attenuated</u> load removed than their costs per <u>attenuated</u> load removal. That is, a technology that removes 100 kg of load upgradient of a freshwater pond will only get credit for removing 50 kg of attenuated load reaching the bay. Considering attenuation, the unit cost per <u>attenuated</u> kilogram is twice the cost per <u>unattenuated</u> kilogram.

IDENTIFICATION OF SCENARIOS

Differing nitrogen removal costs are the driver for nitrogen trading. Towns proposing expensive technologies (*e.g.*, on-site denitrification and PRBs) are likely buyers of nitrogen credits and Towns proposing lower-cost technologies (*e.g.*, sewers) are the likely sellers. More specifically, target buyers of nitrogen credits would be Brewster (related to its potential I/A program) and perhaps Orleans (related to its PRB system). Target sellers would be towns with sewer projects (Chatham, Harwich, and Orleans).

It is also important to consider the expandability of a certain nitrogen removal project. The nitrogen credits gained by Brewster at the Captains Golf Course are very inexpensive, but that project cannot be expanded because of the limits of the golf course.

Similarly, Orleans' low-cost shellfish harvesting project in Lonnies Pond is constrained by the area of the pond available for growing oysters. Thus, these projects are not amenable to nitrogen trading.

Considering all of these factors, the following scenarios are proposed for analysis.

Scenario 1. Brewster and Orleans in their shared sub-watersheds (the River System)

These two towns are the only contributors to six sub-embayments:

- Upper River
- Lower River
- Lonnies Pond
- Arey's Pond
- Namequoit River
- Quanset Pond

The total load removal need is 1,900 kg/yr, with 95% of that removal need being Orleans' responsibility. Brewster's unattenuated loads in those 6 sub-watersheds is 957 kg/yr and that aggregate load is subject to 676 kg/yr of natural attenuation (70%). If Brewster were to install on-site denitrification systems in these sub-watersheds, the cost would be about $720 per un-attenuated pound and about $2,400 per attenuated pound. By comparison, on-site denitrification systems installed in Orleans' portion of these sub-watersheds down-gradient of the natural attenuation sources would cost $720 per attenuated pound.

Orleans has proposed PRBs in these sub-watersheds that are expected to remove only 914 kg/yr of Orleans' 1,805 kg/yr removal commitment. That means that Orleans must either expand its PRB network or identify another technology to address the remaining 891 kg/yr. If that expanded or new technology could remove 986 kg/yr, it would address both towns' needs (95 kg/yr for Brewster and 891 kg/yr for Orleans). Brewster would be responsible for 10% of that cost (95 kg/yr out of 986 kg/yr).

For the purposes of this illustrative example, it is assumed that Orleans will expand its PRB network in these sub-watersheds to fully meet its commitment here and to provide removals on behalf of Brewster. (While PRBs are relatively expensive, the natural attenuation affecting Brewster's loads makes Orleans' PRBs much less expensive than Brewster's I/A systems in this setting).

If Brewster's removal responsibilities are addressed by Orleans in the same sub-watersheds, the Equivalency Factor is 1.0.

Scenario 2. Brewster and Orleans in the Little Pleasant Bay sub-watershed

The Pleasant Bay sub-watershed is the aggregate of four sub-watersheds analyzed in the 2006 MEP study, three of which are aggregated into a single TMDL. Those four sub-watersheds are Pleasant Bay (main), Little Pleasant Bay, Tar Kiln Stream, and the Horseshoe.

In the aggregated Pleasant Bay sub-watershed, there is a removal need of 5,593 kg/yr, of which 3,427 (61%) is attributable to Brewster and Orleans. In the Little Pleasant Bay portion, Brewster and Orleans are the only contributors of nitrogen load.

Other than fertilizer management at Captains Golf Course, the technologies proposed to address Brewster's and Orleans' needs are either expensive or not yet determined. Brewster has put forth a potential I/A program, but its high cost (over $700 per pound) has prompted Brewster to consider other technologies for 891 kg/yr. Orleans needs to expand other options or find a new way to remove 2,310 kg/yr. As the two towns fine-tune their removal plans, they should be watchful for a trade of responsibilities that effects a net savings.

For the purposes of this report, it is assumed that Brewster will identify a technology and sites that can remove 500 kg/yr more than Brewster's sole needs and that the added 500 kg/yr removal will be offered to Orleans to help it fulfill its needs in the Little Pleasant Bay sub-embayment.

Scenario 3. Brewster and Harwich in the Pleasant Bay Main sub-watershed

In the aggregate Pleasant Bay sub-watershed, there is a removal need of 5,593 kg/yr, of which 3,785 (68%) is attributable to Brewster and Harwich.

Brewster's nitrogen removal plan in this sub-watershed is a combination of fertilizer management at the Town-owned Captain's Golf Course (1,160 kg/yr) and (tentatively) 319 on-site denitrification systems in portions of the sub-watershed that are not subject to natural attenuation (981 kg/yr).

Harwich's nitrogen removal plan is focused on public sewers to remove septic nitrogen in four sub-watersheds: Pleasant Bay (1,621 kg/yr), Round Cove (1,209 kg/yr), and Muddy Creek (upper and lower combined 1,577 kg/yr). The recent update of the watershed-embayment model appears to indicate that Harwich's sewering plans in the Muddy Creek sub-watersheds may not need to be as extensive as previously thought. If Harwich could adjust its sewering plan to be less focused on Muddy Creek and more focused on Pleasant Bay, then the added sewering in Pleasant Bay could benefit Brewster and be the subject of a nitrogen credit trade.

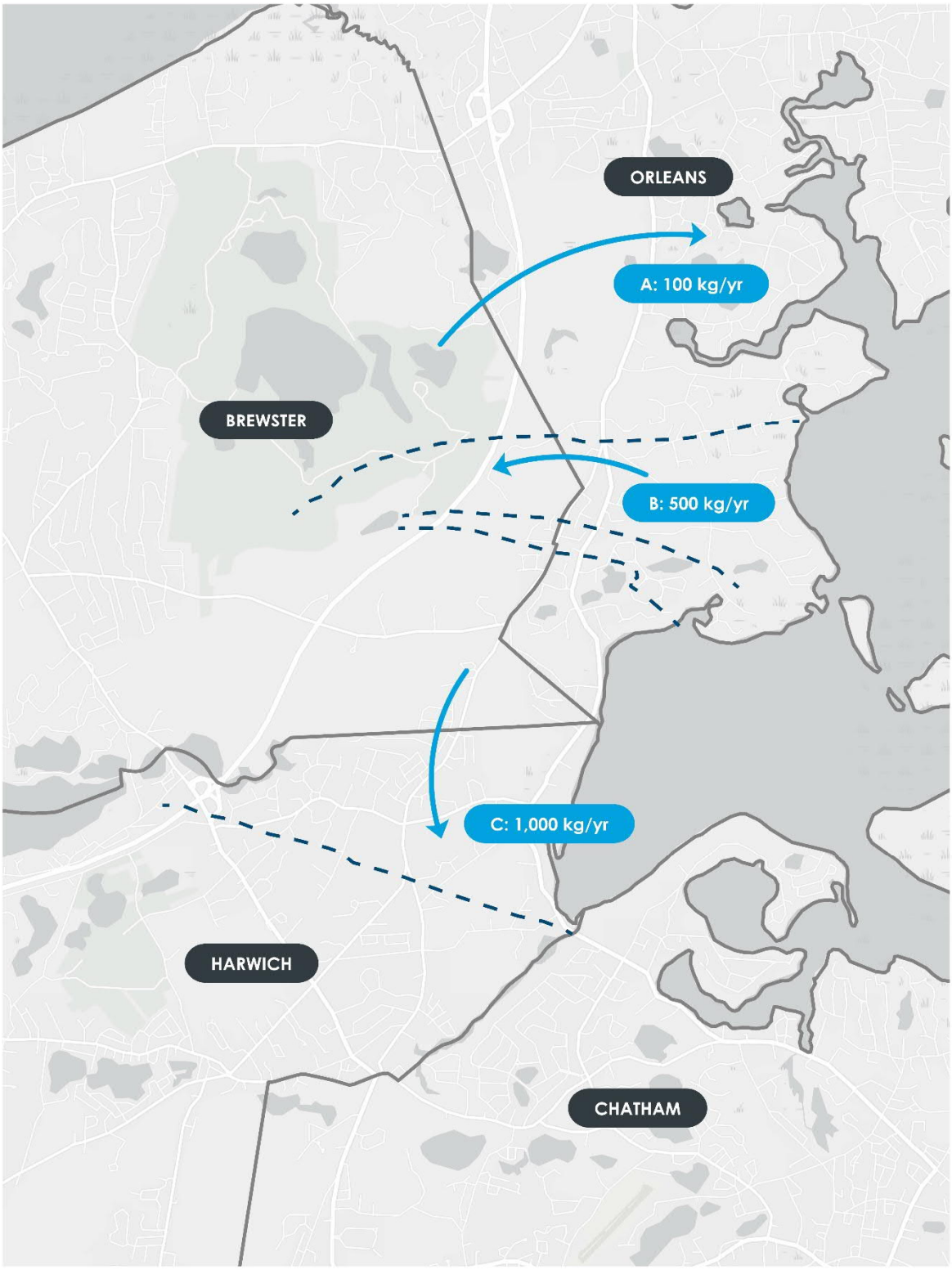
In short, Harwich could "over-remove" nitrogen in its portion of the Pleasant Bay sub-watershed (at a cost of about $350/lb) to allow Brewster to reduce its reliance on on-site denitrification (at about $700/lb).

If Brewster's removal responsibilities are addressed by Harwich in the same sub-watershed, the equivalency factor is 1.0.

Without this hypothetical trade, Harwich flows to the Chatham sewer system are expected to be 220,000 gallons per day (gpd) of the 300,000-gpd capacity allotted by Chatham to Harwich. If Harwich were to expand its sewer system on behalf of Brewster, an additional flow of about 30,000 gpd would result, leaving Harwich with about 50,000 gpd of unused capacity within the Chatham limit.

These hypothetical trades are illustrated in Figure 2. The arrows in Figure 2 represent the transfer of nitrogen removal responsibility between the noted towns.

Figure 2. Transfer of Nitrogen Removal Responsibility



(Scenarios 1 and 2 involve Orleans and Brewster in both Buyer and Seller roles. It would be possible to combine these two scenarios into a single trade. Orleans could "over-remove" nitrogen (100 kg/yr) in the six sub-watersheds it shares only with Brewster (the River System) in exchange for Brewster taking responsibility for 100 kg/yr more removal in the Pleasant Bay sub-watershed.)

ESTIMATES OF COSTS AND SAVINGS

If these nitrogen trading scenarios are brought to fruition, there must be much more detailed analysis than summarized here, and the actual cost savings will depend on the negotiations between Buyer and Seller. To illustrate potential savings and costs, hypothetical "strike prices" (the negotiated price per pound of removal) have been assumed for each scenario. The hypothetical economics are shown in Table 3.

Scenario 1. Brewster and Orleans in their shared sub-watersheds (the River System)

It is assumed, for illustration purposes, that Orleans would expand its proposed PRB network to provide 100 kg/yr extra nitrogen removal for the benefit of Brewster. The hypothetical strike price is $1,600/lb, half way between the $2,400/lb price Brewster would incur for I/A systems (after attenuation) and an assumed $800/lb for additional PRBs in Orleans (that may be slightly more expensive that the ones already selected).

Brewster would pay $352,000 annually to Orleans, one-third less than the cost of the I/A systems Brewster would otherwise implement. With those funds, Orleans would install additional PRBs costing $176,000 per year, and gain a "premium" of $176,000 per year. That premium could be used to offset other components of Orleans' nitrogen management program.

The savings and premium noted above are expressed as equivalent annual costs to include both capital and O&M costs. Alternatively, these figures could be expressed as present worth, the lump sum equivalent to the equivalent annual cost. In these terms, Brewster would save $2.9 million, and Orleans would earn $2.9 million over the $2.9 million cost of the added PRB.

Scenario 2. Brewster and Orleans in the Little Pleasant Bay sub-watershed

Based on the latest SMAST modeling, both Orleans and Brewster fall short of the nitrogen removals needed in the Little Pleasant Bay sub-watershed to restore water quality.

Each town needs to supplement its current nitrogen management program to provide more removal in this sub-watershed. For illustration purposes, it is assumed that Brewster selects a technology that costs $500/lb (say a cluster sewer system and modular treatment plant) and Orleans selects I/A systems at $700/lb. The assumed strike price is $600/lb.

Based on these assumptions, if Brewster could expand its technology to provide 500 kg/yr more removal (for the benefit of Orleans), and negotiations led to a strike price of $600/lb, then Orleans would save $110,000 per year and Brewster would earn $110,000 per year over the cost of the technology expansion. In terms of present worth, the savings and premium are $1.8 million.

Table 3. Savings Associated with Nitrogen Trading Scenarios

	Scenario 1	Scenario 2	Scenario 3
Sub-watershed	River System	Little Pleasant Bay	Pleasant Bay Main
Buyer	Brewster	Orleans	Brewster
Seller	Orleans	Brewster	Harwich
Buyer's technology	I/A systems	Not yet identified	I/A systems
Seller's technology	PRBs	Not yet identified	Sewers
Pre-trade unit costs, $/lb			
Buyer	2,400	700	700
Seller	800	500	350
Strike price, $/lb	1,600	600	525
Trade amount			
kg/yr	100	500	1,000
lb/yr	221	1,103	2,205
Cost to buyer, $/yr	352,000	662,000	1,158,000
Buyer savings, $/yr	176,000	110,000	386,000
Present worth of Buyer savings, $M	2.88	1.80	6.31
Seller income, $/yr	352,000	662,000	1,158,000
Seller costs, $/yr	176,000	552,000	772,000
Seller premium earned, $/yr	176,000	110,000	386,000
Present worth of Seller premium, $M	2.88	1.80	6.31

Scenario 3. Brewster and Harwich in the Pleasant Bay Main sub-watershed

In this scenario, it is assumed that Harwich would expand its sewer system in the Pleasant Bay Main sub-watershed to remove 1,000 kg/yr (by serving an additional 80 homes). For illustration purposes, Harwich's costs are assumed to be $350/lb, compared to Brewster's costs of $700/lb. The negotiated strike price would be $525/lb. Harwich's $13 million (present worth) project would be funded by Brewster as a way to avoid I/A systems that would cost more than that amount. Brewster's savings would be $386,000 per year, and Harwich would earn that same amount to offset other portions of its nitrogen management program.

Summary

Taken together, these three trading scenarios involve 1,600 kg/yr in removal responsibility, or about 9% of the Bay-wide 17,700 kg/yr removal need. The illustrative savings are about $670,000 per year in equivalent annual cost, or about $11 million in present worth. This represents a savings of about 14% of the estimated expenditures currently planned for non-traditional technologies in Orleans and Brewster.

(In these calculations, the strike price is assumed to be midway between the Buyer's and Seller's unit costs, so the Buyer's savings are equal to the premium earned by the Seller. It is likely, however, that the strike price will not be at that midpoint, due to several factors that are specific to the individual circumstances.)

IMPORTANT CONSIDERATIONS

There are many important considerations that must be addressed in a nitrogen credit trade.

The Watershed Permit

The August 2018 Watershed Permit stipulates the nitrogen removal commitments of each of the four towns and sets a schedule for those removals. If one town is to remove less nitrogen, through an agreement with a second town for that town to remove more nitrogen, that arrangement must be codified in the Watershed Permit.

The 20-year Watershed Permit is scheduled to be reviewed each five years to allow changes that may be necessary due to adaptive management. A nitrogen credit trade could be reflected in a revised permit at any of the five-year renewals. The change would not affect the watershed-wide removal but would shift a portion of that removal commitment from one town to another.

Each town's removal commitment must be addressed within the implementation schedule contained in the Watershed Permit. For example, Chatham has committed to removing about 3,400 kg/yr of nitrogen load in years 11 to 15 of the permit. It is presumed that the current removal schedule would remain unchanged if that removal were to be accomplished by another town.

For a nitrogen trade to be reflected in the Watershed Permit, there must be approval by the permitting agency, MassDEP. Therefore, the trading concept, schedule and details should be all be developed with MassDEP involvement.

Intermunicipal Agreements

The details of the nitrogen credit trade must be spelled out in detail in a written agreement between the Buyer and the Seller and would take the form of an inter-municipal agreement (IMA). Such a document should be expected to require considerable time to be developed, due both to the complicated nature of a trade, and the general lack of similar prior executed IMAs to build on. The need for and timing of Town Meeting approvals must be addressed.

The parties should not execute an IMA unless and until MassDEP and the other towns have approved the trade in concept. Further, the Watershed Permit should not be revised to reflect the trade unless and until the two Boards of Selectmen have agreed that the IMA is ready for execution. The IMA and Watershed Permit modification should come to fruition simultaneously.

While an IMA is presumed to be the final form of agreement between the Buyer and the Seller, earlier memoranda of understanding (MOUs) may be advisable to give both parties assurances of the intent to move forward and to expend engineering and legal fees toward the final IMA.

Costs

The unit costs used in this report are based on" equivalent annual cost", the sum of O&M expenses and debt service on the capital costs. It is important to understand that the Buyer would be agreeing to pay the Seller both a portion of the Seller's capital cost and a portion of the Seller's O&M costs.

The trading agreement must address both components of cost. Simplistically, the Buyer would make an up-front payment of a stipulated share of the capital cost (say the cost of building a sewer extension in Harwich in Scenario 3) and an annual payment of the incremental O&M costs of the Seller. Alternatively, the deal could be for a single lump sum payment that combines capital costs and 20 years of O&M. Or the trade could entail an annual payment for a given share of the combination of O&M and debt service. The choice of the payment approach would be determined in the trade negotiations.

Grants and Loans

If a nitrogen removal project is eligible for grants and/or loans, in most cases the funding benefits to the Seller should be passed on to the Buyer. The funding agency should recognize that a separate project by the Buyer could have been implemented at higher cost, and therefore the funding agency should treat the Seller's expanded project as grant/loan-eligible. For example, if Brewster were to implement a nitrogen removal project that would be large enough to satisfy both Brewster's and Orleans' needs in the Little Pleasant Bay sub-watershed (Scenario 2), it is expected that MassDEP would view both the Brewster-only and the expanded Brewster projects as eligible for SRF funding.

If the Seller's project included some features that are not loan-eligible, such as roadway improvements in a sewer project, then the Seller would be obligated to properly account for the eligible and non-eligible costs and pass on the benefits to the Buyer.

Equivalency Factors

The three example trades put forth in this report each occur in a single sub-watershed shared by the Buyer and Seller. In each case the Equivalency Factor is 1.0. There may be other opportunities where trades between subwatersheds is necessary and where nitrogen attenuation is important. In these cases, the Linked Watershed-Embayment model would be used to determine the Equivalency Factors.

Growth in Watershed Load

The nitrogen removal commitments in the Watershed Permit reflect the removals needed to reduce "current' watershed loads (reflective of 2003 to 2006 conditions) to the threshold load determined in the 2006 MEP report. Towns are responsible for those load reductions, plus 100% of any "new" loads that have occurred since 2006 due to development or redevelopment in the watershed. Revisions in the watershed permit over time are expected to address increasing removal requirements due to growth.

An agreement to trade nitrogen credits could address just current removal needs but would be much more effective if growth were considered in the trade. For Scenario 1, Orleans could agree to expand its program by 100 kg/yr to address just Brewster's "current" removal needs in the River System. With growth in watershed loads in Brewster's portion of these subwatersheds, Brewster would still have some obligation beyond the 100 kg/yr handled by Orleans. If Brewster expects, say, 20% growth in watershed loads in those areas, then the trade could cover 120 kg/yr.

Future Changes in Removal Needs

It should be recognized that estuarine modeling and the determination of threshold loads are not exact sciences. For example, changes in the hydrodynamics of the receiving water could result in larger or smaller nitrogen removal requirements than first thought. While the current Watershed Permit reflects the best available estimates of removal needs at the time it was issued, future changes in town-to-town responsibilities should be expected, and these changes must be accounted for in a trading arrangement. In Scenario 3, Harwich must recognize that apparent "over-removals" (based on 2021 modeling results compared with the MEP 2006 report) might be partially reversed in the future. In this example, it would be prudent for Harwich to keep this possibility in mind.

Back-up Plan for Non-Traditional Technologies

Of the seven projects that are part of the current town plans (excluding residential fertilizer controls; see Table 1), only sewering and golf course fertilizer controls are considered to be traditional technologies. The others (on-site denitrification, PRBs and shellfish harvesting) are considered non-traditional and therefore require a back-up plan based on traditional methods. Should Orleans agree to expand its PRB plan to accommodate Brewster loads in the River System (Scenario 1), Orleans would need to expand its back-up plan accordingly. The details of the back-up plan should be spelled out in the IMA, including any associated costs.

Town Recovery of Buyer Costs

For the typical nitrogen removal project, such as sewering, the town must decide how to recover costs that are not covered by grants. Typically, towns decide to recover some of the local capital costs through property taxation and some of the capital costs are borne by users as betterment assessments. O&M costs are typically recovered from users. When a town contracts with another town for nitrogen removal, the Buyer has no "users" to pay betterments or user fees.

The simplest approach would be for the Buyer to pay the Seller from property tax revenues. If there are special benefits that accrue to just some of the property tax payers in the buying town, alternatives should be considered, but may be cumbersome. In this case, financial and legal advisors should be consulted.

Other Agreements

Both the Buyer and the Seller must be aware of other agreements that might impact the potential trade of nitrogen credits. Nitrogen removals dictated by a consent order may not be amenable to a trade, in part due to the needed time needed to negotiate the trade. (There are no known consent orders for nitrogen removal in any of the four towns at this time.) Harwich's wastewater treatment and disposal needs are now met by an agreement with Chatham. Chatham has agreed to receive 300,000 gpd of wastewater flow from Harwich. If Harwich were to engage in a trade with Brewster (Scenario 3 above), the total flow from Harwich must not exceed that 300,000-gpd cap, and Chatham's approval of such a trade is needed under the terms of the Chatham/Harwich IMA.

Public Perceptions

There should be a public consultation process to gain citizen input on a nitrogen trading opportunity. Public support is needed to ensure passage of Town Meeting appropriations that are needed, and for authorization for the IMA.

For the Buyer, the public issues may be simpler, in that construction will be occurring in another town. In Scenario 3 for instance, those property owners in Brewster that would be spared from an I/A system would likely support a proposal to fund expanded sewering in Harwich.

The Seller might expect opposition to public projects that would be more extensive due to a trade. In Scenario 1, for instance, if Orleans expanded its PRB network to accommodate Brewster loads in the River System, Orleans might expect public concerns over the added construction disruption that would occur in Orleans.

The issues associated with nitrogen control are complicated and sometimes controversial. A thorough public consultation process is always beneficial.

MODEL IMA

The contents of an IMA for nitrogen trading must reflect the specific conditions of the trading arrangement and the requirements of each town. Nonetheless, there are many provisions that can be anticipated in a typical IMA, as outlined in Table 4. The issues associated with nitrogen trading

can be complex, and both Buyer and Seller should plan for the time and expense of appropriate legal representation.

Table 4. Elements of an Inter-Municipal Agreement for Nitrogen Trading

Identification of the parties (Buyer and Seller)
Statement of goals
Acknowledgement of relevant prior MOUs and/or IMAs
Citation of applicable laws
Reference to Watershed Permit and identification of its provisions related to this sub-watershed
Identification of nitrogen trade amount (kg/yr) and sub-watershed location
Establishment of payment amounts and timing
Discussion of growth in sub-watershed loads and establishment of associated responsibilities for nitrogen removal
Discussion of potential changes in towns' removal responsibilities related to potential future improved understanding of the Bay's assimilative capacity
Assignment of risks due to underperformance of Seller's technology (added costs for operation and monitoring, early replacement, etc.)
Establishment of a back-up plan for non-traditional technologies
Discussion of grant and loans (trading price reflects current grants or expectations) and Seller's obligation to pursue other grants/subsidies for the benefit of both parties
Language regarding Seller's use of funds
Establishment of date of agreement and duration
Addressing of IMA mechanics (termination, applicable law, acts of God, etc.)

IMPLEMENTATION SCHEDULE

The purpose of this report is to describe the features of a potential nitrogen credit trading program and to use three examples to illustrate some of the specific benefits and constraints. The three examples set forth in this report are not the only possibilities for the Pleasant Bay watershed, and the towns' review of this document may lead to other possibilities being identified. Whether it be one of these three examples or others, it will take some time for a nitrogen trade to be accomplished.

A key feature of such an arrangement is the incorporation of revised town responsibilities into the Watershed Permit. The Permit is structured to allow revisions every five years. August 2021 was the end of the first three years. While it is conceivable that a simple trade might be finalized in the remaining two years of the first 5-year cycle (that is, by August 2023), it is a more realistic expectation that one or more trades might be incorporated in the August 2028 permit renewal.

There is one important step that should be accomplished before there is any detailed consideration of potential trades, and that is the completion of estuary modeling update now underway by SMAST. Recent SMAST tasks include the quantification of the increases in watershed loads, improved hydrodynamics, and natural attenuation changes. These factors may lead to revised threshold loads. If the threshold loads change, then the town's removal requirements will change. The magnitude and location of these changes should be better understood before further work is undertaken on trading opportunities.

Concurrent with the ongoing SMAST work, there will be changes to the towns' removal plans. Orleans should expand its technology selection as appropriate to its planning efforts. Brewster may need to modify its removal plans to account for revised (higher) estimates of attenuation in Tar Kiln Stream. More information is needed on how Harwich's plan may change in the face of a revised (lower) estimate of attenuation in Upper Muddy Creek. Further, traditional back-up plans are needed for all non-traditional projects.

CRITERIA FOR IDENTIFYING TRADING OPPORTUNITIES ELSEWHERE

It is likely that nitrogen trading opportunities exist in many watersheds across Cape Cod. Prime opportunities are where:

- Watersheds span multiple towns
- A range of technologies has been selected by the towns, some of which have expansion capabilities
- The technologies have well-documented costs that cover a significant range of unit costs
- Watershed-embayment modeling is available to estimate equivalency factors when trading opportunities exist between sub-watersheds.

WAY FORWARD

If there is interest in these or other trading scenarios, representatives of each town should meet informally to set forth a plan of action. Next steps would include:

- The parties should prepare an initial MOU to establish responsibilities and expected timing of initial tasks. This document must give both parties the assurance of the other's intent so that each can be comfortable moving forward with expending funds to accomplish the trade.
- The Seller should engage an engineer to refine cost estimates related to the real or expected costs for its existing plan elements, and to estimate the incremental costs of an expanded project to accommodate this trade.
- Concurrently, the Buyer's technical staff and consultants should refine its estimates of costs for the nitrogen removal that Buyer would avoid, so as to have a sound basis for negotiations.
- An attorney should draft the IMA (or in intermediate MOU) to set forth the issues that will influence the price negotiations.
- Each party should provide for public consultation.
- The Seller must determine the permitting requirements for its expanded plan as they impact cost and timing.
- The parties then can negotiate the amount, form, and timing of payments. The essential issues should be documented in an MOU for review by financial and technical advisors and for input from MassDEP related to the Watershed Permit.
- The Seller would then seek Town Meeting approval for appropriations to design and build the expanded facilities.
- Once construction bids are received and O&M budgets are established, the parties can refine the IMA and seek its approval at Town Meetings, including Buyer's appropriation for its costs.
- The Watershed Permit would then be updated to reflect the transfer of responsibility.

It is clear that the Buyer and Seller must work closely to address and resolve technical and financial issues and the significant time is needed to conduct all needed activities with appropriate public consultation and Town Meeting actions.

ACKNOWLEDGMENT

This project was funded by a 2018 Watershed Grant from the Southeast New England Program (SNEP). SNEP is an initiative of the US Environmental Protection Agency and is administered by Restore America's Estuaries. Significant support to this study was provided by the Pleasant Bay Alliance's Watershed Work Group and by the technical consultants for the four watershed towns.

ATTACHMENT U

CLIMATE RESILIENCE DESIGN STANDARDS TOOL PROJECT REPORTS

Climate Resilience Design Standards Tool Project Report

ORLEANS- TOWHEE LANE PUMP STATION

Date Created: 11/16/2023 1:24:26 PM
Created By: Nickgolben1
Date Report Generated: 11/20/2023 4:54:43 PM
Tool Version: Version 1.2
Project Contact Information: Nick Golben (nick.golben@aecom.com)

Project Summary

Link to Project

Estimated Capital Cost: $5000000.00
End of Useful Life Year: 2088
Project within mapped Environmental Justice neighborhood: No

Ecosystem Service Benefits	Scores
Project Score	Low
Exposure	**Scores**
Sea Level Rise/Storm Surge	Not Exposed
Extreme Precipitation - Urban Flooding	Moderate Exposure
Extreme Precipitation - Riverine Flooding	Not Exposed
Extreme Heat	Moderate Exposure



Asset Preliminary Climate Risk Rating Summary

Number of Assets: 1

Asset Risk	Sea Level Rise/Storm Surge	Extreme Precipitation - Urban Flooding	Extreme Precipitation - Riverine Flooding	Extreme Heat
TOWHEE LANE PUMP STATION	Low Risk	High Risk	Low Risk	High Risk

Climate Resilience Design Standards Summary

	Target Planning Horizon	Intermediate Planning Horizon	Percentile	Return Period	Tier
Sea Level Rise/Storm Surge					
TOWHEE LANE PUMP STATION					
Extreme Precipitation					
TOWHEE LANE PUMP STATION	2070			50-yr (2%)	Tier 3
Extreme Heat					
TOWHEE LANE PUMP STATION	2070		90th		Tier 3

Scoring Rationale - Project Exposure Score

The purpose of the Exposure Score output is to provide a preliminary assessment of whether the overall project site and subsequent assets are exposed to impacts of natural hazard events and/or future impacts of climate change. For each climate parameter, the Tool will calculate one of the following exposure ratings: Not Exposed, Low Exposure, Moderate Exposure, or High Exposure. The rationale behind the exposure rating is provided below.

Sea Level Rise/Storm Surge

This project received a "Not Exposed" because of the following:

- Not located within the predicted mean high water shoreline by 2030
- No historic coastal flooding at project site
- Not located within the Massachusetts Coast Flood Risk Model (MC-FRM)

Extreme Precipitation - Urban Flooding

This project received a "Moderate Exposure" because of the following:

- Maximum annual daily rainfall exceeds 10 inches within the overall project's useful life
- No historic flooding at project site
- No increase to impervious area
- Existing impervious area of the project site is less than 10%

Extreme Precipitation - Riverine Flooding

This project received a "Not Exposed" because of the following:

- No historic riverine flooding at project site
- The project is not within a mapped FEMA floodplain [outside of the Massachusetts Coast Flood Risk Model (MC-FRM)]
- Project is more than 500ft from a waterbody
- Project is not likely susceptible to riverine erosion

Extreme Heat

This project received a "Moderate Exposure" because of the following:

- Existing impervious area of the project site is less than 10%
- 10 to 30 day increase in days over 90 deg. F within project's useful life
- Located within 100 ft of existing water body
- No increase to the impervious area of the project site
- No tree removal

Scoring Rationale - Asset Preliminary Climate Risk Rating

A Preliminary Climate Risk Rating is determined for each infrastructure and building asset by considering the overall project Exposure Score and responses to Step 4 questions provided by the user in the Tool. Natural Resource assets do not receive a risk rating. The following factors are what influenced the risk ratings for each asset.

Asset - TOWHEE LANE PUMP STATION
Primary asset criticality factors influencing risk ratings for this asset:

- Asset must be operable at all times, even during natural hazard event
- Greater than 10,000 people would be directly affected by the loss/inoperability of the asset
- The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
- Inoperability of the asset would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses
- Inoperability is likely to significantly impact other facilities, assets, or buildings and will likely affect their ability to operate
- Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety

Project Climate Resilience Design Standards Output

Climate Resilience Design Standards and Guidance are recommended for each asset and climate parameter. The Design Standards for each climate parameter include the following: recommended planning horizon (target and/or intermediate), recommended return period (Sea Level Rise/Storm Surge and Precipitation) or percentile (Heat), and a list of applicable design criteria that are likely to be affected by climate change. Some design criteria have numerical values associated with the recommended return period and planning horizon, while others have tiered methodologies with step-by-step instructions on how to estimate design values given the other recommended design standards.

Asset: TOWHEE LANE PUMP STATION — Building/Facility

Sea Level Rise/Storm Surge — Low Risk

Applicable Design Criteria

Projected Tidal Datums: NOT APPLICABLE

Projected Water Surface Elevation: NOT APPLICABLE

Projected Wave Action Water Elevation: NOT APPLICABLE

Projected Wave Heights: NOT APPLICABLE

Projected Duration of Flooding: NOT APPLICABLE

Projected Design Flood Velocity: NOT APPLICABLE

Projected Scour & Erosion: NOT APPLICABLE

Extreme Precipitation — High Risk

Target Planning Horizon: 2070
Return Period: 50-yr (2%)

LIMITATIONS: The recommended Standards for Total Precipitation Depth & Peak Intensity are determined by the user drawn polygon and relationships as defined in the Supporting Documents. The projected Total Precipitation Depth values provided through the Tool are based on the climate projections developed by Cornell University as part of EEA's Massachusetts Climate and Hydrologic Risk Project, GIS-based data as of 10/15/21. For additional information on the methodology of these precipitation outputs, see Supporting Documents.

While Total Precipitation Depth & Peak Intensity for 24-hour Design Storms are useful to inform planning and design, it is recommended to also consider additional longer- and shorter-duration precipitation events and intensities in accordance with best practices. Longer-duration, lower-intensity storms allow time for infiltration and reduce the load on infrastructure over the duration of the storm. Shorter-duration, higher-intensity storms often have higher runoff volumes because the water does not have enough time to infiltrate infrastructure systems (e.g., catch basins) and may overflow or back up during such storms, resulting in flooding. In the Northeast, short-duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. While the Tool does not provide recommended design standards for these scenarios, users should still consider both short- and long-duration precipitation events and how they may impact the asset.

The projected values, standards, and guidance provided within this Tool may be used to inform plans and designs, but they do not provide guarantees for future conditions or resilience. The projected values are not to be considered final or appropriate for construction documents without supporting engineering analyses. The guidance provided within this Tool is intended to be general and users are encouraged to do their own due diligence

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
TOWHEE LANE PUMP STATION	2070	50-Year (2%)	8.2	Downloadable Methodology PDF

Projected Riverine Peak Discharge & Peak Flood Elevation: NOT APPLICABLE

Extreme Heat — High Risk

Target Planning Horizon: 2070
Percentile: 90th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Annual/Summer/Winter Average Temperatures: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Heat Index: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Growing Degree Days: NOT APPLICABLE

Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Number of Heat Waves Per Year & Average Heat Wave Duration: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Cooling Degree Days & Heating Degree Days (base = 65°F): APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Project Inputs

Core Project Information

Name:	ORLEANS- TOWHEE LANE PUMP STATION
Given the expected useful life of the project, through what year do you estimate the project to last (i.e. before a major reconstruction/renovation)?	2088
Location of Project:	Orleans
Estimated Capital Cost:	$5,000,000
Who is the Submitting Entity?	Private Other AECOM Nick Golben (nick.golben@aecom.com)
Is this project being submitted as part of a state grant application?	No
Which grant program?	
What stage are you in your project lifecycle?	Pre-Planning
Is climate resiliency a core objective of this project?	Yes
Is this project being submitted as part of the state capital planning process?	No
Is this project being submitted as part of a regulatory review process or permitting?	Yes
Brief Project Description:	Identify risk considerations when planning, designing, and constructing wastewater infrastructure that will improve water quality in Orleans.
Project Submission Comments:	

Project Ecosystem Service Benefits

Factors Influencing Output

- ✓ Project improves water quality
- ✓ Project protects fisheries, wildlife, and plant habitat
- ✓ Project protects land containing shellfish
- ✓ Project remediates existing sources of pollution
- ✓ Project prevents pollution

Factors to Improve Output

- ✓ Incorporate nature-based solutions that may provide flood protection
- ✓ Incorporate nature-based solutions that may reduce storm damage
- ✓ Protect public water supply by reducing the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption
- ✓ Incorporate strategies that reduce carbon emissions
- ✓ Incorporate green infrastructure or nature-based solutions that recharge groundwater
- ✓ Incorporate green infrastructure to filter stormwater
- ✓ Incorporate nature-based solutions that sequester carbon carbon
- ✓ Incorporate vegetation that provides pollinator habitat
- ✓ Provide opportunities for passive and/or active recreation through open space
- ✓ Increase plants, trees, and/or other vegetation to provide oxygen production
- ✓ Mitigate atmospheric greenhouse gas concentrations and other toxic air pollutants through nature-based solutions
- ✓ Incorporate education and/or protect cultural resources as part of your project

Is the primary purpose of this project ecological restoration?

No

Project Benefits

Provides flood protection through nature-based solutions	No
Reduces storm damage	No
Recharges groundwater	No
Protects public water supply	No
Filters stormwater using green infrastructure	No
Improves water quality	Yes
Promotes decarbonization	No
Enables carbon sequestration	No
Provides oxygen production	No
Improves air quality	No
Prevents pollution	Yes
Remediates existing sources of pollution	Yes
Protects fisheries, wildlife, and plant habitat	Yes
Protects land containing shellfish	Yes
Provides pollinator habitat	No
Provides recreation	No
Provides cultural resources/education	No

Project Climate Exposure

Is the primary purpose of this project ecological restoration?	No

Does the project site have a history of coastal flooding?	No
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	Unsure
Does the project site have a history of riverine flooding?	No
Does the project result in a net increase in impervious area of the site?	Unsure
Are existing trees being removed as part of the proposed project?	Unsure

Project Assets

Asset: TOWHEE LANE PUMP STATION
Asset Type: Typically Unoccupied
Asset Sub-Type: Pump Station - Sanitary
Construction Type: New Construction
Construction Year: 2038
Useful Life: 50

Identify the length of time the asset can be inaccessible/inoperable without significant consequences.
Building must be accessible/operable at all times, even during natural hazard event

Identify the geographic area directly affected by permanent loss or significant inoperability of the building/facility.
Impacts would be regional (more than one municipality and/or surrounding region)

Identify the population directly served that would be affected by the permanent loss of use or inoperability of the building/facility.
Greater than 10,000 people

Identify if the building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.

If the building/facility became inoperable for longer than acceptable in Question 1, how, if at all, would it be expected to impact people's health and safety?
Inoperability of the building/facility would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses

If there are hazardous materials in your building/facility, what are the extent of impacts related to spills/releases of these materials?
Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety (E.g. wastewater treatment plant; biohazard laboratory)

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts on other facilities, assets, and/or infrastructure?
Significant – Inoperability is likely to impact other facilities, assets, or buildings and will likely affect their ability to operate

If this building/facility was damaged beyond repair, how much would it approximately cost to replace?
Between $10 million and $30 million

Is this a recreational facility which can be vacated during a natural hazard event?
No

If the building/facility became inoperable for longer than acceptable in Question 1, what are the public and/or social services impacts?
No alternative programs and/or services are available to support the community

If the building/facility became inoperable for longer than acceptable in Question 1, what are the environmental impacts related to natural resources?
Impact on natural resources will require remediation/rehabilitation

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to government services (i.e. the building is not able to serve or operate its intended users or function)?
Loss of building may reduce the ability to maintain some government services, while a majority of services will still exist.

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to loss of confidence in government (i.e. the building is not able to serve or operate its intended users or function)?
Loss of confidence in government agency

Report Comments

N/A

Climate Resilience Design Standards Tool Project Report

ORLEANS- ROCK HARBOR ROAD PUMP STATION

Date Created: 11/16/2023 2:00:34 PM
Created By: Nickgolben1
Date Report Generated: 11/20/2023 4:56:36 PM
Tool Version: Version 1.2
Project Contact Information: Nick Golben (nick.golben@aecom.com)

Project Summary

Link to Project

Estimated Capital Cost: $5000000.00
End of Useful Life Year: 2115
Project within mapped Environmental Justice neighborhood: No

Ecosystem Service Benefits	Scores
Project Score	Low
Exposure	**Scores**
Sea Level Rise/Storm Surge	Moderate Exposure
Extreme Precipitation - Urban Flooding	High Exposure
Extreme Precipitation - Riverine Flooding	Not Exposed
Extreme Heat	Moderate Exposure



Asset Preliminary Climate Risk Rating Summary

Number of Assets: 1

Asset Risk	Sea Level Rise/Storm Surge	Extreme Precipitation - Urban Flooding	Extreme Precipitation - Riverine Flooding	Extreme Heat
ROCK HARBOR ROAD PUMP STATION	High Risk	High Risk	Low Risk	High Risk

Climate Resilience Design Standards Summary

	Target Planning Horizon	Intermediate Planning Horizon	Percentile	Return Period	Tier
Sea Level Rise/Storm Surge					
ROCK HARBOR ROAD PUMP STATION	2070	2050		500-yr (0.2%)	
Extreme Precipitation					
ROCK HARBOR ROAD PUMP STATION	2070			50-yr (2%)	Tier 3
Extreme Heat					
ROCK HARBOR ROAD PUMP STATION	2070		90th		Tier 3

Scoring Rationale - Project Exposure Score

The purpose of the Exposure Score output is to provide a preliminary assessment of whether the overall project site and subsequent assets are exposed to impacts of natural hazard events and/or future impacts of climate change. For each climate parameter, the Tool will calculate one of the following exposure ratings: Not Exposed, Low Exposure, Moderate Exposure, or High Exposure. The rationale behind the exposure rating is provided below.

Sea Level Rise/Storm Surge

This project received a "Moderate Exposure" because of the following:

- Exposed to the 1% annual coastal flood event as early as 2030
- Located within the 0.1% annual coastal flood event within the project's useful life
- Not located within the predicted mean high water shoreline by 2030

Extreme Precipitation - Urban Flooding

This project received a "High Exposure" because of the following:

- Maximum annual daily rainfall exceeds 10 inches within the overall project's useful life
- No historic flooding at project site
- No increase to impervious area
- Existing impervious area of the project site is between 10% and 50%

Extreme Precipitation - Riverine Flooding

This project received a "Not Exposed" because of the following:

- No historic riverine flooding at project site
- The project is not within a mapped FEMA floodplain [outside of the Massachusetts Coast Flood Risk Model (MC-FRM)]
- Project is more than 500ft from a waterbody
- Project is not likely susceptible to riverine erosion

Extreme Heat

This project received a "Moderate Exposure" because of the following:

- Existing impervious area of the project site is between 10% and 50%
- 10 to 30 day increase in days over 90 deg. F within project's useful life
- Located within 100 ft of existing water body
- No increase to the impervious area of the project site
- No tree removal

Scoring Rationale - Asset Preliminary Climate Risk Rating

A Preliminary Climate Risk Rating is determined for each infrastructure and building asset by considering the overall project Exposure Score and responses to Step 4 questions provided by the user in the Tool. Natural Resource assets do not receive a risk rating. The following factors are what influenced the risk ratings for each asset.

Asset - ROCK HARBOR ROAD PUMP STATION
Primary asset criticality factors influencing risk ratings for this asset:

- Asset must be operable at all times, even during natural hazard event
- Greater than 10,000 people would be directly affected by the loss/inoperability of the asset
- The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
- Inoperability of the asset would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses
- Inoperability is likely to significantly impact other facilities, assets, or buildings and will likely affect their ability to operate
- Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety

Project Climate Resilience Design Standards Output

Climate Resilience Design Standards and Guidance are recommended for each asset and climate parameter. The Design Standards for each climate parameter include the following: recommended planning horizon (target and/or intermediate), recommended return period (Sea Level Rise/Storm Surge and Precipitation) or percentile (Heat), and a list of applicable design criteria that are likely to be affected by climate change. Some design criteria have numerical values associated with the recommended return period and planning horizon, while others have tiered methodologies with step-by-step instructions on how to estimate design values given the other recommended design standards.

Asset: ROCK HARBOR ROAD PUMP STATION — Building/Facility

Sea Level Rise/Storm Surge — High Risk

Target Planning Horizon: 2070
Intermediate Planning Horizon: 2050
Return Period: 500-yr (0.2%)

LIMITATIONS: The recommended Climate Resilience Design Standards for the Sea Level Rise / Storm Surge Design Criteria are based on the user drawn polygon and relationships as defined in the Supporting Documents. The projected values provided through the Tool are based on the Massachusetts Coast Flood Risk Model (MC-FRM) outputs as of 9/13/2021, which included GIS-based data for three planning horizons (2030, 2050, 2070) and six return periods (0.1%, 0.2%, 0.5%, 1%, 2%, 5%). These values are projections based on assumptions as defined in the model and the LiDAR used at the time. For additional information on the MC-FRM, review the additional resources provided on the Start Here page.

The projected values, Standards, and Guidance provided within this Tool may be used to inform plans and designs, but they do not provide guarantees for future conditions or resilience. The projected values are not to be considered final or appropriate for construction documents without supporting engineering analyses. The guidance provided within this Tool is intended to be general and users are encouraged to do their own due diligence.

Applicable Design Criteria

Projected Tidal Datums: APPLICABLE
Note: The site is exposed to Sea Level Rise/Storm Surge, but projected Tidal Datums are not available within the site. Additional site-specific analyses are recommended to identify projected Tidal Datums for the recommended planning horizon. Consult a professional coastal engineer or modeler to estimate projected Tidal Datums based on the recommended Standards and additional outputs provided through this Tool.

Projected Water Surface Elevation: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period	Max	Min	Area Weighted Average
			(ft - NAVD88)		
ROCK HARBOR ROAD PUMP STATION	2050	0.2% (500-Year)	15.2	15.2	15.2
	2070		16.8	16.8	16.8

Projected Wave Action Water Elevation: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period	Max	Min	Area Weighted Average
			(ft - NAVD88)		
ROCK HARBOR ROAD PUMP STATION	2050	0.2% (500-Year)	17.1	16.3	16.7
	2070		19.8	18.7	19.1

Projected Wave Heights: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period	Max	Min	Area Weighted Average
			(Feet)		
ROCK HARBOR ROAD PUMP STATION	2050	0.2% (500-Year)	2.5	1.5	2.0
	2070		4.0	2.5	3.1

Projected Duration of Flooding: APPLICABLE
Methodology to Estimate Projected Values

Projected Design Flood Velocity: APPLICABLE
Methodology to Estimate Projected Values

Projected Scour & Erosion: NOT APPLICABLE

Extreme Precipitation — High Risk

Target Planning Horizon: 2070
Return Period: 50-yr (2%)

LIMITATIONS: The recommended Standards for Total Precipitation Depth & Peak Intensity are determined by the user drawn polygon and relationships as defined in the Supporting Documents. The projected Total Precipitation Depth values provided through the Tool are based on the climate projections developed by Cornell University as part of EEA's Massachusetts Climate and Hydrologic Risk Project, GIS-based data as of 10/15/21. For additional information on the methodology of these precipitation outputs, see Supporting Documents.

While Total Precipitation Depth & Peak Intensity for 24-hour Design Storms are useful to inform planning and design, it is recommended to also consider additional longer- and shorter-duration precipitation events and intensities in accordance with best practices. Longer-duration, lower-intensity storms allow time for infiltration and reduce the load on infrastructure over the duration of the storm. Shorter-duration, higher-intensity storms often have higher runoff volumes because the water does not have enough time to infiltrate infrastructure systems (e.g., catch basins) and may overflow or back up during such storms, resulting in flooding. In the Northeast, short-duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. While the Tool does not provide recommended design standards for these scenarios, users should still consider both short- and long-duration precipitation events and how they may impact the asset.

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Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
ROCK HARBOR ROAD PUMP STATION	2070	50-Year (2%)	8.2	Downloadable Methodology PDF

Projected Riverine Peak Discharge & Peak Flood Elevation: NOT APPLICABLE

Extreme Heat — High Risk

Target Planning Horizon: 2070
Percentile: 90th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Annual/Summer/Winter Average Temperatures: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Heat Index: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Growing Degree Days: NOT APPLICABLE

Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Number of Heat Waves Per Year & Average Heat Wave Duration: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Cooling Degree Days & Heating Degree Days (base = 65°F): APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Sea Level Rise/Storm Surge Project Maps

The following three maps illustrate the Projected Water Surface Elevation for the 2030, 2050, and 2070 planning horizons corresponding to the lowest return period (largest design storm) recommended across the assets identified for this project in the Tool. For projects that only have Natural Resource assets, the maps will show the Projected Water Surface Elevations corresponding to the 5% (20-year) return period. Refer to the Climate Resilience Design Standards Output - Sea Level Rise/Storm Surge Section for additional values associated with other assets. The maps include the project area as drawn by the user with a 0.1 mile minimum buffer, but do not reflect the location of specific assets on the site.

LIMITATIONS: The recommended Climate Resilience Design Standards for the Sea Level Rise / Storm Surge Design Criteria are based on the user drawn polygon and relationships as defined in the Supporting Documents. The projected values and maps provided through the Tool are based on the Massachusetts Coast Flood Risk Model (MC-FRM) outputs as of 9/13/2021, which included GIS-based data for three planning horizons (2030, 2050, 2070) and six return periods (0.1%, 0.2%, 0.5%, 1%, 2%, 5%). These values are projections based on assumptions as defined in the model and the LiDAR used at the time. For additional information on the MC-FRM, review the additional resources provided on the Start Here page.

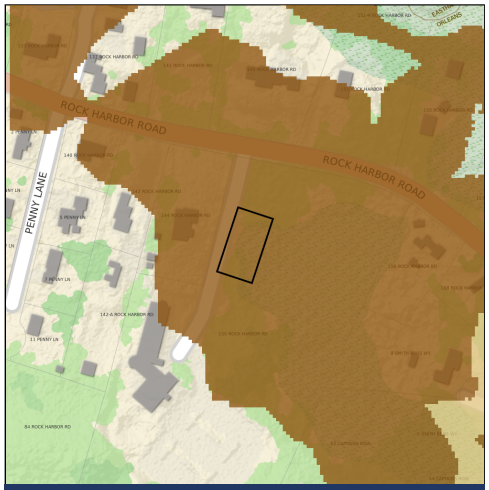
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Legend

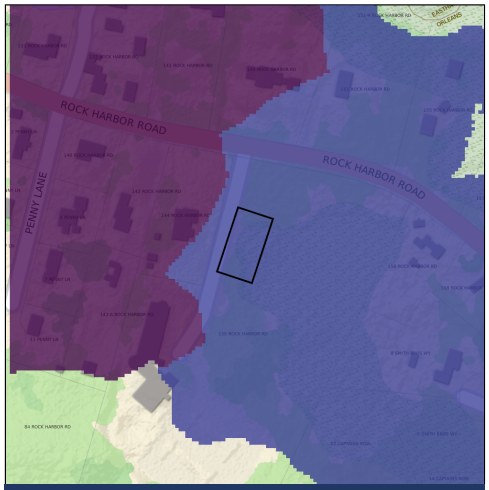
- Project Boundary

Projected Water Surface Elevation (ft-NAVD88)

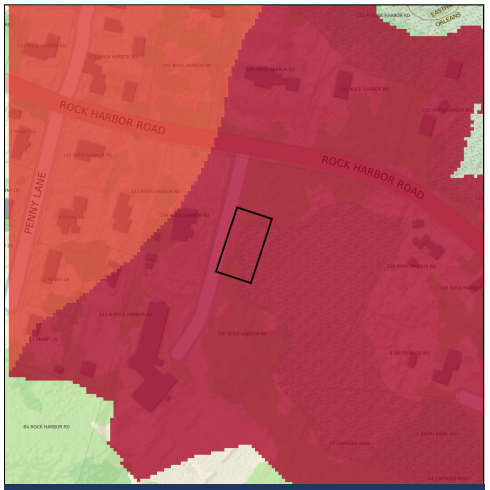
- ≤ 12.3
- 12.3 - 12.4
- 12.4 - 12.6
- 12.6 - 12.8
- 12.8 - 13.0
- 13.0 - 13.2
- 13.2 - 13.4
- 13.4 - 13.6
- 13.6 - 13.8
- 13.8 - 14.0
- 14.0 - 14.2
- 14.2 - 14.4
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- 15.0 - 15.2
- 15.2 - 15.4
- 15.4 - 15.6
- 15.6 - 15.8
- 15.8 - 16.0
- 16.0 - 16.2
- 16.2 - 16.4
- 16.4 - 16.6
- 16.6 - 16.8
- ≥ 16.8



2030



2050



2070

Climate Resilience Design Standards Tool:
Sea Level Rise/Storm Surge Design Criteria
Projected Water Surface Elevation Map: 0.2% (500-yr)

Project Name: ORLEANS- ROCK HARBOR ROAD PUMP STATION
Location (Town): Orleans

0.25 0.5 1.0 Miles

Created by: Nickgolben1
Date Created: 11/16/2023
Tool Version: 1.3

N

Asset Name	Planning Horizon	Return Period	Max	Min	Area Weighted Average (ft-NAVD88)
ROCK HARBOR ROAD PUMP STATION	2030	0.2% (500-yr)	12.3	12.3	12.3
	2050	0.2% (500-yr)	15.2	15.2	15.2
	2070	0.2% (500-yr)	16.8	16.8	16.8



Climate Resilience Design Standards Tool:
Sea Level Rise/Storm Surge Design Criteria
Projected Water Surface Elevation Map: 2030, 0.2% (500-yr)

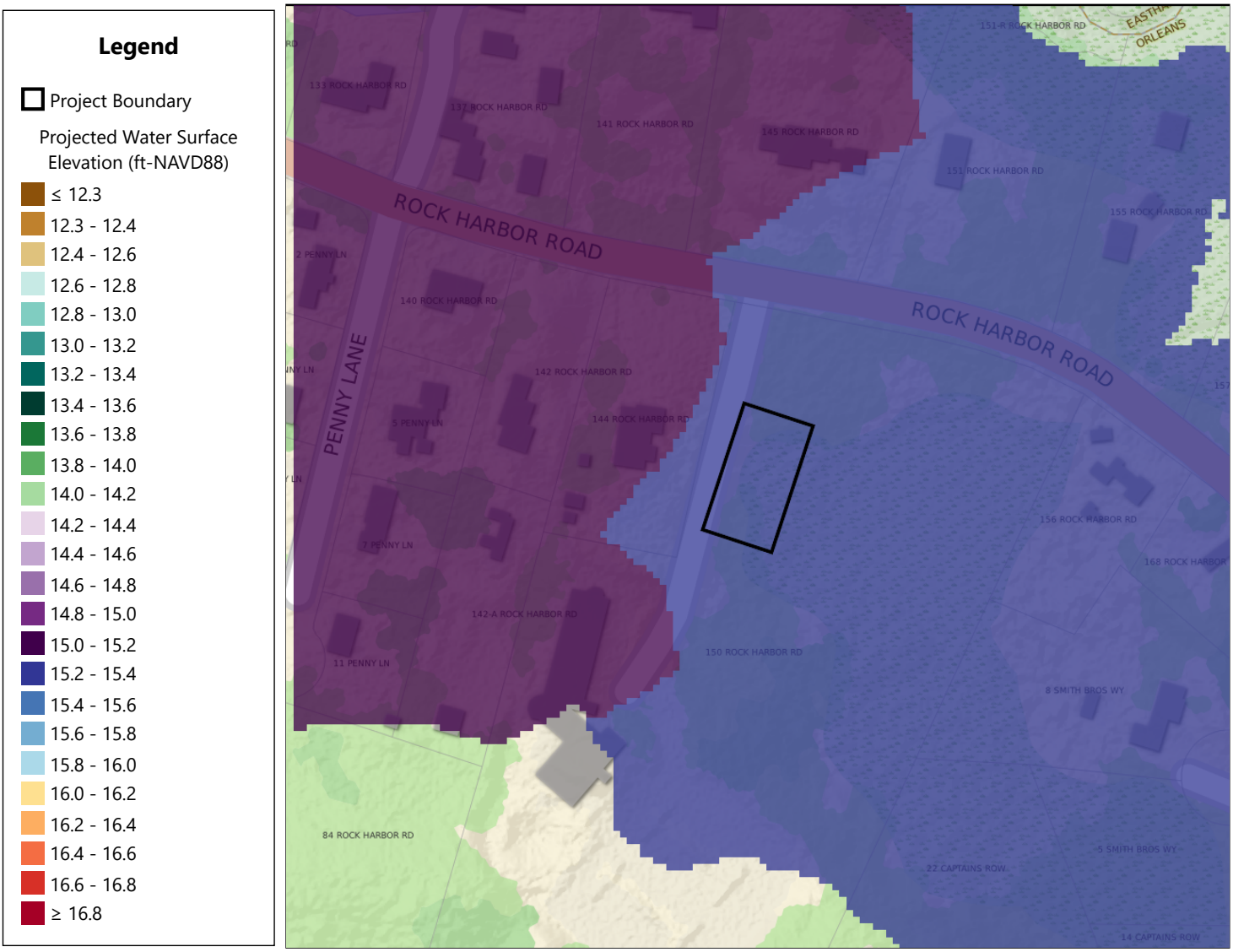
Project Name: ORLEANS- ROCK HARBOR ROAD PUMP STATION
Location (Town): Orleans

0.05 0.1 0.25 Miles

Created by: Nickgolben1
Date Created: 11/16/2023
Tool Version: 1.3

N

Asset Name	Planning Horizon	Return Period	Max	Min	Area Weighted Average (ft-NAVD88)
ROCK HARBOR ROAD PUMP STATION	2030	0.2% (500-yr)	12.3	12.3	12.3



Climate Resilience Design Standards Tool:
Sea Level Rise/Storm Surge Design Criteria
Projected Water Surface Elevation Map: 2050, 0.2% (500-yr)

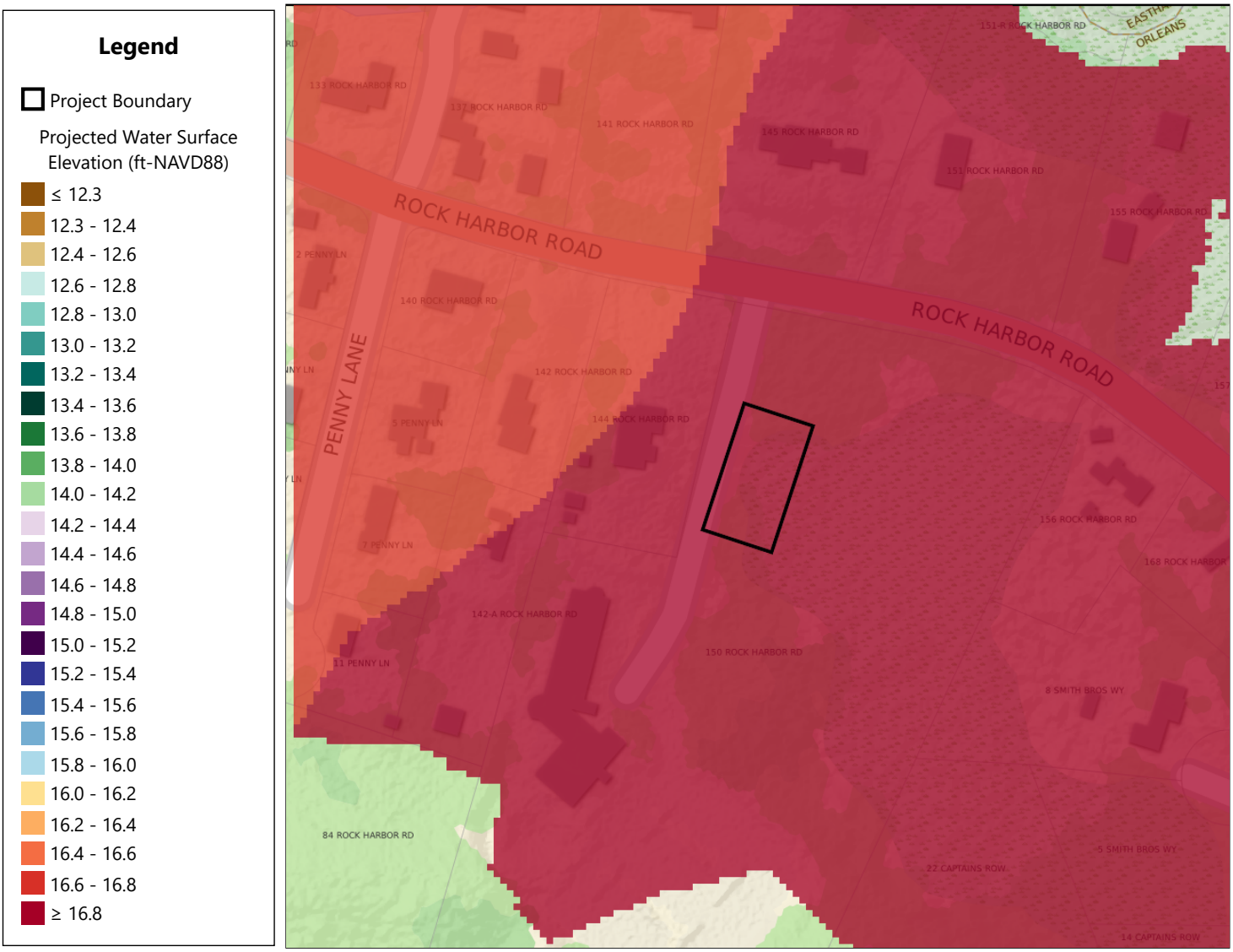
Project Name: ORLEANS- ROCK HARBOR ROAD PUMP STATION
Location (Town): Orleans

0.05 0.1 0.25 Miles

Created by: Nickgolben1
Date Created: 11/16/2023
Tool Version: 1.3

N

Asset Name	Planning Horizon	Return Period	Max	Min	Area Weighted Average (ft-NAVD88)
ROCK HARBOR ROAD PUMP STATION	2050	0.2% (500-yr)	15.2	15.2	15.2



Climate Resilience Design Standards Tool:
Sea Level Rise/Storm Surge Design Criteria
Projected Water Surface Elevation Map: 2070, 0.2% (500-yr)

Project Name: ORLEANS- ROCK HARBOR ROAD PUMP STATION
Location (Town): Orleans

0.05 0.1 0.25 Miles

Created by: Nickgolben1
Date Created: 11/16/2023
Tool Version: 1.3

N

Asset Name	Planning Horizon	Return Period	Max	Min	Area Weighted Average (ft-NAVD88)
ROCK HARBOR ROAD PUMP STATION	2070	0.2% (500-yr)	16.8	16.8	16.8

Project Inputs

Core Project Information

Name:	ORLEANS- ROCK HARBOR ROAD PUMP STATION
Given the expected useful life of the project, through what year do you estimate the project to last (i.e. before a major reconstruction/renovation)?	2115
Location of Project:	Orleans
Estimated Capital Cost:	$5,000,000
Who is the Submitting Entity?	Private Other AECOM Nick Golben (nick.golben@aecom.com)
Is this project being submitted as part of a state grant application?	No
Which grant program?	
What stage are you in your project lifecycle?	Pre-Planning
Is climate resiliency a core objective of this project?	Yes
Is this project being submitted as part of the state capital planning process?	No
Is this project being submitted as part of a regulatory review process or permitting?	Yes
Brief Project Description:	Identify risk considerations when planning, designing, and constructing wastewater infrastructure that will improve water quality in Orleans.
Project Submission Comments:	

Project Ecosystem Service Benefits

Factors Influencing Output

- ✓ Project improves water quality
- ✓ Project protects fisheries, wildlife, and plant habitat
- ✓ Project protects land containing shellfish
- ✓ Project remediates existing sources of pollution
- ✓ Project prevents pollution

Factors to Improve Output

- ✓ Incorporate nature-based solutions that may provide flood protection
- ✓ Incorporate nature-based solutions that may reduce storm damage
- ✓ Protect public water supply by reducing the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption
- ✓ Incorporate strategies that reduce carbon emissions
- ✓ Incorporate green infrastructure or nature-based solutions that recharge groundwater
- ✓ Incorporate green infrastructure to filter stormwater
- ✓ Incorporate nature-based solutions that sequester carbon carbon
- ✓ Incorporate vegetation that provides pollinator habitat
- ✓ Provide opportunities for passive and/or active recreation through open space
- ✓ Increase plants, trees, and/or other vegetation to provide oxygen production
- ✓ Mitigate atmospheric greenhouse gas concentrations and other toxic air pollutants through nature-based solutions
- ✓ Incorporate education and/or protect cultural resources as part of your project

Is the primary purpose of this project ecological restoration?

No

Project Benefits

Provides flood protection through nature-based solutions	No
Reduces storm damage	No
Recharges groundwater	No
Protects public water supply	No
Filters stormwater using green infrastructure	No
Improves water quality	Yes
Promotes decarbonization	No
Enables carbon sequestration	No
Provides oxygen production	No
Improves air quality	No
Prevents pollution	Yes
Remediates existing sources of pollution	Yes
Protects fisheries, wildlife, and plant habitat	Yes
Protects land containing shellfish	Yes
Provides pollinator habitat	No
Provides recreation	No
Provides cultural resources/education	No

Project Climate Exposure

Is the primary purpose of this project ecological restoration?	No

Does the project site have a history of coastal flooding?	No
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	Unsure
Does the project site have a history of riverine flooding?	No
Does the project result in a net increase in impervious area of the site?	Unsure
Are existing trees being removed as part of the proposed project?	Unsure

Project Assets

Asset: ROCK HARBOR ROAD PUMP STATION
Asset Type: Typically Unoccupied
Asset Sub-Type: Pump Station - Sanitary
Construction Type: New Construction
Construction Year: 2065
Useful Life: 50

Identify the length of time the asset can be inaccessible/inoperable without significant consequences.
Building must be accessible/operable at all times, even during natural hazard event

Identify the geographic area directly affected by permanent loss or significant inoperability of the building/facility.
Impacts would be regional (more than one municipality and/or surrounding region)

Identify the population directly served that would be affected by the permanent loss of use or inoperability of the building/facility.
Greater than 10,000 people

Identify if the building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.

If the building/facility became inoperable for longer than acceptable in Question 1, how, if at all, would it be expected to impact people's health and safety?
Inoperability of the building/facility would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses

If there are hazardous materials in your building/facility, what are the extent of impacts related to spills/releases of these materials?
Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety (E.g. wastewater treatment plant; biohazard laboratory)

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts on other facilities, assets, and/or infrastructure?
Significant – Inoperability is likely to impact other facilities, assets, or buildings and will likely affect their ability to operate

If this building/facility was damaged beyond repair, how much would it approximately cost to replace?
Between $10 million and $30 million

Is this a recreational facility which can be vacated during a natural hazard event?
No

If the building/facility became inoperable for longer than acceptable in Question 1, what are the public and/or social services impacts?
No alternative programs and/or services are available to support the community

If the building/facility became inoperable for longer than acceptable in Question 1, what are the environmental impacts related to natural resources?
Impact on natural resources will require remediation/rehabilitation

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to government services (i.e. the building is not able to serve or operate its intended users or function)?
Loss of building may reduce the ability to maintain some government services, while a majority of services will still exist.

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to loss of confidence in government (i.e. the building is not able to serve or operate its intended users or function)?
Loss of confidence in government agency

Report Comments

N/A

Climate Resilience Design Standards Tool Project Report

ORLEANS- NAMEQUOIT ROAD PUMP STATION

Date Created: 11/16/2023 1:14:29 PM
Created By: Nickgolben1
Date Report Generated: 11/20/2023 4:54:22 PM
Tool Version: Version 1.2
Project Contact Information: Nick Golben (nick.golben@aecom.com)

Project Summary

Link to Project

Estimated Capital Cost: $5000000.00
End of Useful Life Year: 2085
Project within mapped Environmental Justice neighborhood: No

Ecosystem Service Benefits	Scores
Project Score	Low
Exposure	**Scores**
Sea Level Rise/Storm Surge	High Exposure
Extreme Precipitation - Urban Flooding	Moderate Exposure
Extreme Precipitation - Riverine Flooding	Not Exposed
Extreme Heat	Moderate Exposure



Asset Preliminary Climate Risk Rating Summary

Number of Assets: 1

Asset Risk	Sea Level Rise/Storm Surge	Extreme Precipitation - Urban Flooding	Extreme Precipitation - Riverine Flooding	Extreme Heat
NAMEQUOIT ROAD PUMP STATION	High Risk	High Risk	Low Risk	High Risk

Climate Resilience Design Standards Summary

	Target Planning Horizon	Intermediate Planning Horizon	Percentile	Return Period	Tier
Sea Level Rise/Storm Surge					
NAMEQUOIT ROAD PUMP STATION	2070	2050		500-yr (0.2%)	
Extreme Precipitation					
NAMEQUOIT ROAD PUMP STATION	2070			50-yr (2%)	Tier 3
Extreme Heat					
NAMEQUOIT ROAD PUMP STATION	2070		90th		Tier 3

Scoring Rationale - Project Exposure Score

The purpose of the Exposure Score output is to provide a preliminary assessment of whether the overall project site and subsequent assets are exposed to impacts of natural hazard events and/or future impacts of climate change. For each climate parameter, the Tool will calculate one of the following exposure ratings: Not Exposed, Low Exposure, Moderate Exposure, or High Exposure. The rationale behind the exposure rating is provided below.

Sea Level Rise/Storm Surge

This project received a "High Exposure" because of the following:

- Located within the predicted mean high water shoreline by 2030
- Exposed to the 1% annual coastal flood event as early as 2030
- Located within the 0.1% annual coastal flood event within the project's useful life

Extreme Precipitation - Urban Flooding

This project received a "Moderate Exposure" because of the following:

- Maximum annual daily rainfall exceeds 10 inches within the overall project's useful life
- No historic flooding at project site
- No increase to impervious area
- Existing impervious area of the project site is less than 10%

Extreme Precipitation - Riverine Flooding

This project received a "Not Exposed" because of the following:

- No historic riverine flooding at project site
- The project is not within a mapped FEMA floodplain [outside of the Massachusetts Coast Flood Risk Model (MC-FRM)]
- Project is more than 500ft from a waterbody
- Project is not likely susceptible to riverine erosion

Extreme Heat

This project received a "Moderate Exposure" because of the following:

- Existing impervious area of the project site is less than 10%
- 10 to 30 day increase in days over 90 deg. F within project's useful life
- Located within 100 ft of existing water body
- No increase to the impervious area of the project site
- No tree removal

Scoring Rationale - Asset Preliminary Climate Risk Rating

A Preliminary Climate Risk Rating is determined for each infrastructure and building asset by considering the overall project Exposure Score and responses to Step 4 questions provided by the user in the Tool. Natural Resource assets do not receive a risk rating. The following factors are what influenced the risk ratings for each asset.

Asset - NAMEQUOIT ROAD PUMP STATION
Primary asset criticality factors influencing risk ratings for this asset:

- Asset must be operable at all times, even during natural hazard event
- Greater than 10,000 people would be directly affected by the loss/inoperability of the asset
- The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
- Inoperability of the asset would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses
- Inoperability is likely to significantly impact other facilities, assets, or buildings and will likely affect their ability to operate
- Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety

Project Climate Resilience Design Standards Output

Climate Resilience Design Standards and Guidance are recommended for each asset and climate parameter. The Design Standards for each climate parameter include the following: recommended planning horizon (target and/or intermediate), recommended return period (Sea Level Rise/Storm Surge and Precipitation) or percentile (Heat), and a list of applicable design criteria that are likely to be affected by climate change. Some design criteria have numerical values associated with the recommended return period and planning horizon, while others have tiered methodologies with step-by-step instructions on how to estimate design values given the other recommended design standards.

Asset: NAMEQUOIT ROAD PUMP STATION — Building/Facility

Sea Level Rise/Storm Surge — High Risk

Target Planning Horizon: 2070
Intermediate Planning Horizon: 2050
Return Period: 500-yr (0.2%)

LIMITATIONS: The recommended Climate Resilience Design Standards for the Sea Level Rise / Storm Surge Design Criteria are based on the user drawn polygon and relationships as defined in the Supporting Documents. The projected values provided through the Tool are based on the Massachusetts Coast Flood Risk Model (MC-FRM) outputs as of 9/13/2021, which included GIS-based data for three planning horizons (2030, 2050, 2070) and six return periods (0.1%, 0.2%, 0.5%, 1%, 2%, 5%). These values are projections based on assumptions as defined in the model and the LiDAR used at the time. For additional information on the MC-FRM, review the additional resources provided on the Start Here page.

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Applicable Design Criteria

Projected Tidal Datums: APPLICABLE
This project is located in an area with uncertainty for future tidal datums. These uncertain zones are either dynamic in terms of geomorphology or are restricted by manmade features (i.e., culverts, tide gates, etc.) that should be evaluated in more detail at the site-scale.

Projected Water Surface Elevation: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period	Max	Min	Area Weighted Average
			(ft - NAVD88)		
NAMEQUOIT ROAD PUMP STATION	2050	0.2% (500-Year)	14.3	14.3	14.3
	2070		15.6	15.6	15.6

Projected Wave Action Water Elevation: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period	Max	Min	Area Weighted Average
			(ft - NAVD88)		
NAMEQUOIT ROAD PUMP STATION	2050	0.2% (500-Year)	18.0	14.3	16.2
	2070		20.1	15.6	17.6

Projected Wave Heights: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period	Max	Min	Area Weighted Average
			(Feet)		
NAMEQUOIT ROAD PUMP STATION	2050	0.2% (500-Year)	5.5	0.0	2.7
	2070		6.0	0.0	2.8

Projected Duration of Flooding: APPLICABLE
Methodology to Estimate Projected Values

Projected Design Flood Velocity: APPLICABLE
Methodology to Estimate Projected Values

Projected Scour & Erosion: NOT APPLICABLE

Extreme Precipitation — High Risk

Target Planning Horizon: 2070
Return Period: 50-yr (2%)

LIMITATIONS: The recommended Standards for Total Precipitation Depth & Peak Intensity are determined by the user drawn polygon and relationships as defined in the Supporting Documents. The projected Total Precipitation Depth values provided through the Tool are based on the climate projections developed by Cornell University as part of EEA's Massachusetts Climate and Hydrologic Risk Project, GIS-based data as of 10/15/21. For additional information on the methodology of these precipitation outputs, see Supporting Documents.

While Total Precipitation Depth & Peak Intensity for 24-hour Design Storms are useful to inform planning and design, it is recommended to also consider additional longer- and shorter-duration precipitation events and intensities in accordance with best practices. Longer-duration, lower-intensity storms allow time for infiltration and reduce the load on infrastructure over the duration of the storm. Shorter-duration, higher-intensity storms often have higher runoff volumes because the water does not have enough time to infiltrate infrastructure systems (e.g., catch basins) and may overflow or back up during such storms, resulting in flooding. In the Northeast, short-duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. While the Tool does not provide recommended design standards for these scenarios, users should still consider both short- and long-duration precipitation events and how they may impact the asset.

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Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
NAMEQUOIT ROAD PUMP STATION	2070	50-Year (2%)	8.2	Downloadable Methodology PDF

Projected Riverine Peak Discharge & Peak Flood Elevation: NOT APPLICABLE

Extreme Heat — High Risk

Target Planning Horizon: 2070
Percentile: 90th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Annual/Summer/Winter Average Temperatures: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Heat Index: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Growing Degree Days: NOT APPLICABLE

Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Number of Heat Waves Per Year & Average Heat Wave Duration: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Cooling Degree Days & Heating Degree Days (base = 65°F): APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Sea Level Rise/Storm Surge Project Maps

The following three maps illustrate the Projected Water Surface Elevation for the 2030, 2050, and 2070 planning horizons corresponding to the lowest return period (largest design storm) recommended across the assets identified for this project in the Tool. For projects that only have Natural Resource assets, the maps will show the Projected Water Surface Elevations corresponding to the 5% (20-year) return period. Refer to the Climate Resilience Design Standards Output - Sea Level Rise/Storm Surge Section for additional values associated with other assets. The maps include the project area as drawn by the user with a 0.1 mile minimum buffer, but do not reflect the location of specific assets on the site.

LIMITATIONS: The recommended Climate Resilience Design Standards for the Sea Level Rise / Storm Surge Design Criteria are based on the user drawn polygon and relationships as defined in the Supporting Documents. The projected values and maps provided through the Tool are based on the Massachusetts Coast Flood Risk Model (MC-FRM) outputs as of 9/13/2021, which included GIS-based data for three planning horizons (2030, 2050, 2070) and six return periods (0.1%, 0.2%, 0.5%, 1%, 2%, 5%). These values are projections based on assumptions as defined in the model and the LiDAR used at the time. For additional information on the MC-FRM, review the additional resources provided on the Start Here page.

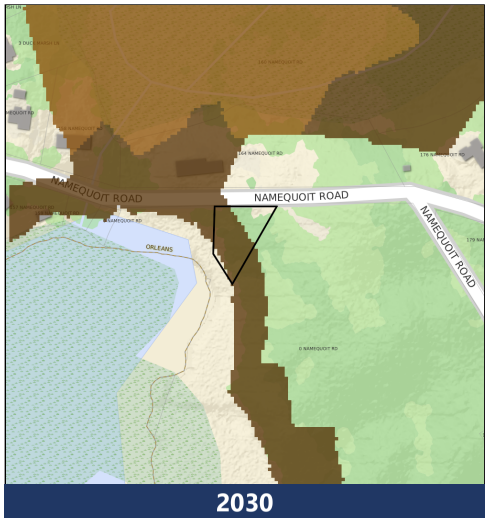
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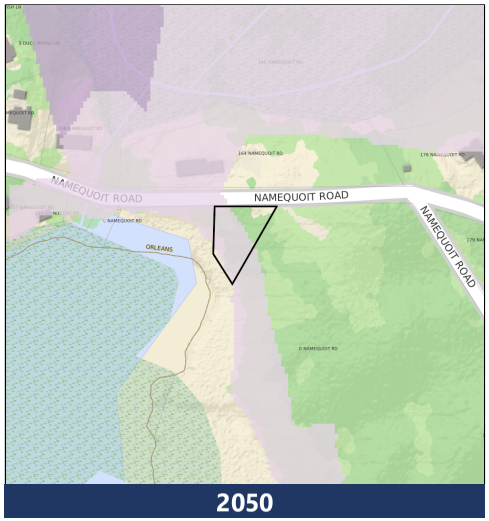
Legend

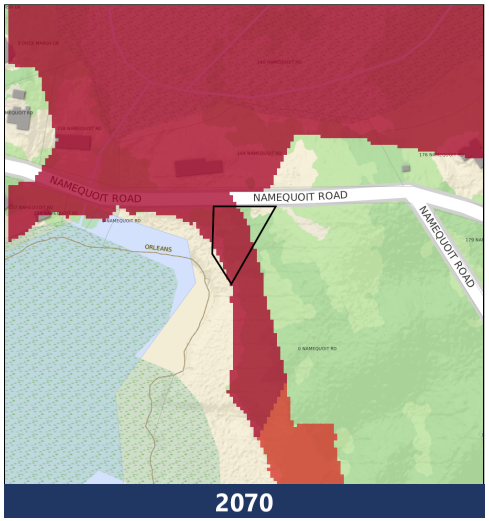
- Project Boundary

Projected Water Surface Elevation (ft-NAVD88)

- ≤ 13.2
- 13.2 - 13.3
- 13.3 - 13.4
- 13.4 - 13.5
- 13.5 - 13.6
- 13.6 - 13.7
- 13.7 - 13.8
- 13.8 - 13.9
- 13.9 - 14.0
- 14.0 - 14.1
- 14.1 - 14.2
- 14.2 - 14.3
- 14.3 - 14.4
- 14.4 - 14.5
- 14.5 - 14.6
- 14.6 - 14.7
- 14.7 - 14.8
- 14.8 - 14.9
- 14.9 - 15.0
- 15.0 - 15.1
- 15.1 - 15.2
- 15.2 - 15.3
- 15.3 - 15.4
- 15.4 - 15.5
- 15.5 - 15.6
- ≥ 15.6







Climate Resilience Design Standards Tool:
Sea Level Rise/Storm Surge Design Criteria
Projected Water Surface Elevation Map: 0.2% (500-yr)

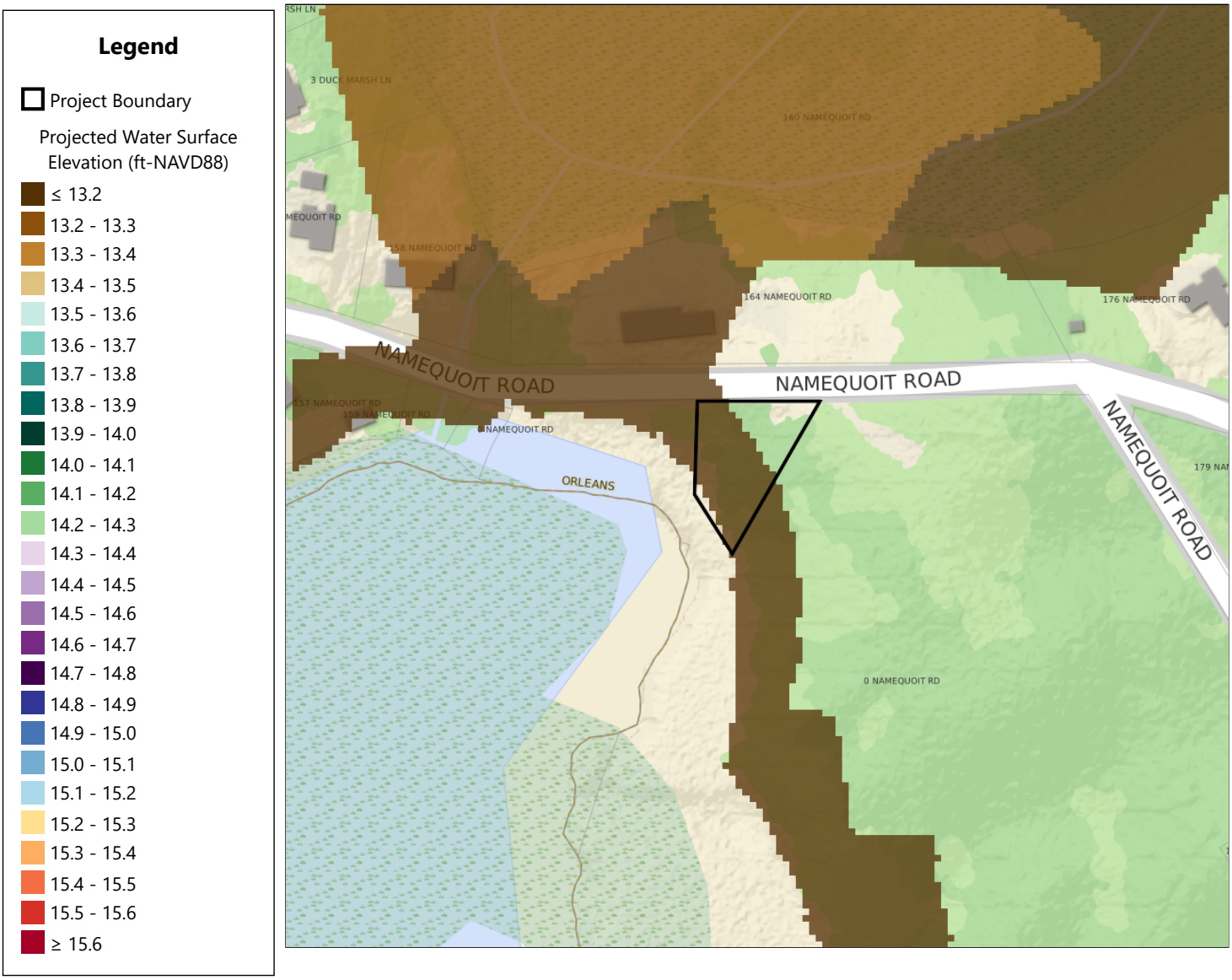
Project Name: ORLEANS- NAMEQUOIT ROAD PUMP STATION
Location (Town): Orleans

0.25 0.5 1.0 Miles

Created by: Nickgolben1
Date Created: 11/16/2023
Tool Version: 1.3

N

Asset Name	Planning Horizon	Return Period	Max	Min	Area Weighted Average (ft-NAVD88)
NAMEQUOIT ROAD PUMP STATION	2030	0.2% (500-yr)	13.1	13.1	13.1
	2050	0.2% (500-yr)	14.3	14.3	14.3
	2070	0.2% (500-yr)	15.6	15.6	15.6



Climate Resilience Design Standards Tool:
Sea Level Rise/Storm Surge Design Criteria
Projected Water Surface Elevation Map: 2030, 0.2% (500-yr)

Project Name: ORLEANS- NAMEQUOIT ROAD PUMP STATION
Location (Town): Orleans

0.05 0.1 0.25 Miles

Created by: Nickgolben1
Date Created: 11/16/2023
Tool Version: 1.3

N

Asset Name	Planning Horizon	Return Period	Max	Min	Area Weighted Average (ft-NAVD88)
NAMEQUOIT ROAD PUMP STATION	2030	0.2% (500-yr)	13.1	13.1	13.1



Climate Resilience Design Standards Tool:
Sea Level Rise/Storm Surge Design Criteria
Projected Water Surface Elevation Map: 2050, 0.2% (500-yr)

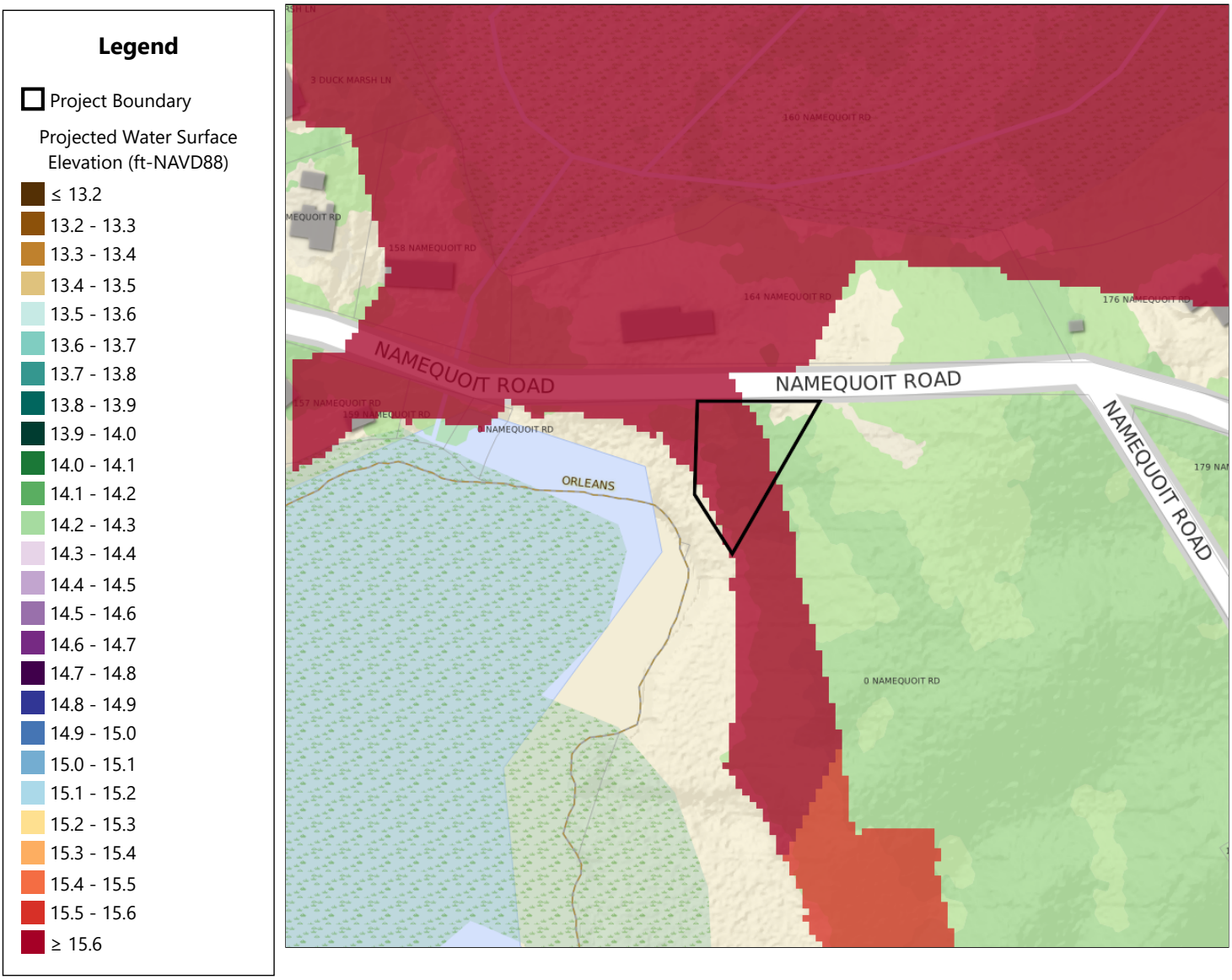
Project Name: ORLEANS- NAMEQUOIT ROAD PUMP STATION
Location (Town): Orleans

0.05 0.1 0.25 Miles

Created by: Nickgolben1
Date Created: 11/16/2023
Tool Version: 1.3

N

Asset Name	Planning Horizon	Return Period	Max	Min	Area Weighted Average (ft-NAVD88)
NAMEQUOIT ROAD PUMP STATION	2050	0.2% (500-yr)	14.3	14.3	14.3



Climate Resilience Design Standards Tool:
Sea Level Rise/Storm Surge Design Criteria
Projected Water Surface Elevation Map: 2070, 0.2% (500-yr)

Project Name: ORLEANS- NAMEQUOIT ROAD PUMP STATION
Location (Town): Orleans

0.05 0.1 0.25 Miles

Created by: Nickgolben1
Date Created: 11/16/2023
Tool Version: 1.3

N

Asset Name	Planning Horizon	Return Period	Max	Min	Area Weighted Average (ft-NAVD88)
NAMEQUOIT ROAD PUMP STATION	2070	0.2% (500-yr)	15.6	15.6	15.6

Project Inputs

Core Project Information

Name:	ORLEANS- NAMEQUOIT ROAD PUMP STATION
Given the expected useful life of the project, through what year do you estimate the project to last (i.e. before a major reconstruction/renovation)?	2085
Location of Project:	Orleans
Estimated Capital Cost:	$5,000,000
Who is the Submitting Entity?	Private Other AECOM Nick Golben (nick.golben@aecom.com)
Is this project being submitted as part of a state grant application?	No
Which grant program?	
What stage are you in your project lifecycle?	Pre-Planning
Is climate resiliency a core objective of this project?	Yes
Is this project being submitted as part of the state capital planning process?	No
Is this project being submitted as part of a regulatory review process or permitting?	Yes
Brief Project Description:	Identify risk considerations when planning, designing, and constructing wastewater infrastructure that will improve water quality in Orleans.
Project Submission Comments:	

Project Ecosystem Service Benefits

Factors Influencing Output

- ✓ Project improves water quality
- ✓ Project protects fisheries, wildlife, and plant habitat
- ✓ Project protects land containing shellfish
- ✓ Project remediates existing sources of pollution
- ✓ Project prevents pollution

Factors to Improve Output

- ✓ Incorporate nature-based solutions that may provide flood protection
- ✓ Incorporate nature-based solutions that may reduce storm damage
- ✓ Protect public water supply by reducing the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption
- ✓ Incorporate strategies that reduce carbon emissions
- ✓ Incorporate green infrastructure or nature-based solutions that recharge groundwater
- ✓ Incorporate green infrastructure to filter stormwater
- ✓ Incorporate nature-based solutions that sequester carbon carbon
- ✓ Incorporate vegetation that provides pollinator habitat
- ✓ Provide opportunities for passive and/or active recreation through open space
- ✓ Increase plants, trees, and/or other vegetation to provide oxygen production
- ✓ Mitigate atmospheric greenhouse gas concentrations and other toxic air pollutants through nature-based solutions
- ✓ Incorporate education and/or protect cultural resources as part of your project

Is the primary purpose of this project ecological restoration?

No

Project Benefits

Provides flood protection through nature-based solutions	No
Reduces storm damage	No
Recharges groundwater	No
Protects public water supply	No
Filters stormwater using green infrastructure	No
Improves water quality	Yes
Promotes decarbonization	No
Enables carbon sequestration	No
Provides oxygen production	No
Improves air quality	No
Prevents pollution	Yes
Remediates existing sources of pollution	Yes
Protects fisheries, wildlife, and plant habitat	Yes
Protects land containing shellfish	Yes
Provides pollinator habitat	No
Provides recreation	No
Provides cultural resources/education	No

Project Climate Exposure

Is the primary purpose of this project ecological restoration?	No

Does the project site have a history of coastal flooding?	No
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	Unsure
Does the project site have a history of riverine flooding?	No
Does the project result in a net increase in impervious area of the site?	Unsure
Are existing trees being removed as part of the proposed project?	Unsure

Project Assets

Asset: NAMEQUOIT ROAD PUMP STATION
Asset Type: Typically Unoccupied
Asset Sub-Type: Pump Station - Sanitary
Construction Type: New Construction
Construction Year: 2035
Useful Life: 50

Identify the length of time the asset can be inaccessible/inoperable without significant consequences.
Building must be accessible/operable at all times, even during natural hazard event

Identify the geographic area directly affected by permanent loss or significant inoperability of the building/facility.
Impacts would be regional (more than one municipality and/or surrounding region)

Identify the population directly served that would be affected by the permanent loss of use or inoperability of the building/facility.
Greater than 10,000 people

Identify if the building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.

If the building/facility became inoperable for longer than acceptable in Question 1, how, if at all, would it be expected to impact people's health and safety?
Inoperability of the building/facility would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses

If there are hazardous materials in your building/facility, what are the extent of impacts related to spills/releases of these materials?
Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety (E.g. wastewater treatment plant; biohazard laboratory)

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts on other facilities, assets, and/or infrastructure?
Significant – Inoperability is likely to impact other facilities, assets, or buildings and will likely affect their ability to operate

If this building/facility was damaged beyond repair, how much would it approximately cost to replace?
Between $10 million and $30 million

Is this a recreational facility which can be vacated during a natural hazard event?
No

If the building/facility became inoperable for longer than acceptable in Question 1, what are the public and/or social services impacts?
No alternative programs and/or services are available to support the community

If the building/facility became inoperable for longer than acceptable in Question 1, what are the environmental impacts related to natural resources?
Impact on natural resources will require remediation/rehabilitation

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to government services (i.e. the building is not able to serve or operate its intended users or function)?
Loss of building may reduce the ability to maintain some government services, while a majority of services will still exist.

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to loss of confidence in government (i.e. the building is not able to serve or operate its intended users or function)?
Loss of confidence in government agency

Report Comments

N/A

Climate Resilience Design Standards Tool Project Report

ORLEANS- LAKE DRIVE PUMP STATION

Date Created: 11/16/2023 1:04:29 PM
Created By: Nickgolben1
Date Report Generated: 11/20/2023 4:53:50 PM
Tool Version: Version 1.2
Project Contact Information: Nick Golben (nick.golben@aecom.com)

Project Summary

Link to Project

Estimated Capital Cost: $5000000.00
End of Useful Life Year: 2082
Project within mapped Environmental Justice neighborhood: No

Ecosystem Service Benefits	Scores
Project Score	Low
Exposure	**Scores**
Sea Level Rise/Storm Surge	Not Exposed
Extreme Precipitation - Urban Flooding	Moderate Exposure
Extreme Precipitation - Riverine Flooding	Moderate Exposure
Extreme Heat	Moderate Exposure



Asset Preliminary Climate Risk Rating Summary

Number of Assets: 1

Asset Risk	Sea Level Rise/Storm Surge	Extreme Precipitation - Urban Flooding	Extreme Precipitation - Riverine Flooding	Extreme Heat
LAKE DRIVE PUMP STATION	Low Risk	High Risk	High Risk	High Risk

Climate Resilience Design Standards Summary

	Target Planning Horizon	Intermediate Planning Horizon	Percentile	Return Period	Tier
Sea Level Rise/Storm Surge					
LAKE DRIVE PUMP STATION					
Extreme Precipitation					
LAKE DRIVE PUMP STATION	2070			50-yr (2%)	Tier 3
Extreme Heat					
LAKE DRIVE PUMP STATION	2070		90th		Tier 3

Scoring Rationale - Project Exposure Score

The purpose of the Exposure Score output is to provide a preliminary assessment of whether the overall project site and subsequent assets are exposed to impacts of natural hazard events and/or future impacts of climate change. For each climate parameter, the Tool will calculate one of the following exposure ratings: Not Exposed, Low Exposure, Moderate Exposure, or High Exposure. The rationale behind the exposure rating is provided below.

Sea Level Rise/Storm Surge

This project received a "Not Exposed" because of the following:

- Not located within the predicted mean high water shoreline by 2030
- No historic coastal flooding at project site
- Not located within the Massachusetts Coast Flood Risk Model (MC-FRM)

Extreme Precipitation - Urban Flooding

This project received a "Moderate Exposure" because of the following:

- Maximum annual daily rainfall exceeds 10 inches within the overall project's useful life
- No historic flooding at project site
- No increase to impervious area
- Existing impervious area of the project site is less than 10%

Extreme Precipitation - Riverine Flooding

This project received a "Moderate Exposure" because of the following:

- Part of the project is within 200ft of a waterbody and less than 30ft above the waterbody
- No historic riverine flooding at project site
- The project is not within a mapped FEMA floodplain [outside of the Massachusetts Coast Flood Risk Model (MC-FRM)]
- Project is not likely susceptible to riverine erosion

Extreme Heat

This project received a "Moderate Exposure" because of the following:

- Existing impervious area of the project site is less than 10%
- 10 to 30 day increase in days over 90 deg. F within project's useful life
- Located within 100 ft of existing water body
- No increase to the impervious area of the project site
- No tree removal

Scoring Rationale - Asset Preliminary Climate Risk Rating

A Preliminary Climate Risk Rating is determined for each infrastructure and building asset by considering the overall project Exposure Score and responses to Step 4 questions provided by the user in the Tool. Natural Resource assets do not receive a risk rating. The following factors are what influenced the risk ratings for each asset.

Asset - LAKE DRIVE PUMP STATION
Primary asset criticality factors influencing risk ratings for this asset:

- Asset must be operable at all times, even during natural hazard event
- Greater than 10,000 people would be directly affected by the loss/inoperability of the asset
- The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
- Inoperability of the asset would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses
- Inoperability is likely to significantly impact other facilities, assets, or buildings and will likely affect their ability to operate
- Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety

Project Climate Resilience Design Standards Output

Climate Resilience Design Standards and Guidance are recommended for each asset and climate parameter. The Design Standards for each climate parameter include the following: recommended planning horizon (target and/or intermediate), recommended return period (Sea Level Rise/Storm Surge and Precipitation) or percentile (Heat), and a list of applicable design criteria that are likely to be affected by climate change. Some design criteria have numerical values associated with the recommended return period and planning horizon, while others have tiered methodologies with step-by-step instructions on how to estimate design values given the other recommended design standards.

Asset: LAKE DRIVE PUMP STATION — Building/Facility

Sea Level Rise/Storm Surge — Low Risk

Applicable Design Criteria

Projected Tidal Datums: NOT APPLICABLE

Projected Water Surface Elevation: NOT APPLICABLE

Projected Wave Action Water Elevation: NOT APPLICABLE

Projected Wave Heights: NOT APPLICABLE

Projected Duration of Flooding: NOT APPLICABLE

Projected Design Flood Velocity: NOT APPLICABLE

Projected Scour & Erosion: NOT APPLICABLE

Extreme Precipitation — High Risk

Target Planning Horizon: 2070
Return Period: 50-yr (2%)

LIMITATIONS: The recommended Standards for Total Precipitation Depth & Peak Intensity are determined by the user drawn polygon and relationships as defined in the Supporting Documents. The projected Total Precipitation Depth values provided through the Tool are based on the climate projections developed by Cornell University as part of EEA's Massachusetts Climate and Hydrologic Risk Project, GIS-based data as of 10/15/21. For additional information on the methodology of these precipitation outputs, see Supporting Documents.

While Total Precipitation Depth & Peak Intensity for 24-hour Design Storms are useful to inform planning and design, it is recommended to also consider additional longer- and shorter-duration precipitation events and intensities in accordance with best practices. Longer-duration, lower-intensity storms allow time for infiltration and reduce the load on infrastructure over the duration of the storm. Shorter-duration, higher-intensity storms often have higher runoff volumes because the water does not have enough time to infiltrate infrastructure systems (e.g., catch basins) and may overflow or back up during such storms, resulting in flooding. In the Northeast, short-duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. While the Tool does not provide recommended design standards for these scenarios, users should still consider both short- and long-duration precipitation events and how they may impact the asset.

The projected values, standards, and guidance provided within this Tool may be used to inform plans and designs, but they do not provide guarantees for future conditions or resilience. The projected values are not to be considered final or appropriate for construction documents without supporting engineering analyses. The guidance provided within this Tool is intended to be general and users are encouraged to do their own due diligence

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
LAKE DRIVE PUMP STATION	2070	50-Year (2%)	8.2	Downloadable Methodology PDF

Projected Riverine Peak Discharge & Peak Flood Elevation: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Extreme Heat High Risk

Target Planning Horizon: 2070
Percentile: 90th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Annual/Summer/Winter Average Temperatures: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Heat Index: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Growing Degree Days: NOT APPLICABLE

Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Number of Heat Waves Per Year & Average Heat Wave Duration: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Cooling Degree Days & Heating Degree Days (base = 65°F): APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Project Inputs

Core Project Information

Name:	ORLEANS- LAKE DRIVE PUMP STATION
Given the expected useful life of the project, through what year do you estimate the project to last (i.e. before a major reconstruction/renovation)?	2082
Location of Project:	Orleans
Estimated Capital Cost:	$5,000,000
Who is the Submitting Entity?	Private Other AECOM Nick Golben (nick.golben@aecom.com)
Is this project being submitted as part of a state grant application?	No
Which grant program?	
What stage are you in your project lifecycle?	Pre-Planning
Is climate resiliency a core objective of this project?	Yes
Is this project being submitted as part of the state capital planning process?	No
Is this project being submitted as part of a regulatory review process or permitting?	Yes
Brief Project Description:	Identify risk considerations when planning, designing, and constructing wastewater infrastructure that will improve water quality in Orleans.
Project Submission Comments:	

Project Ecosystem Service Benefits

Factors Influencing Output

- ✓ Project improves water quality
- ✓ Project protects fisheries, wildlife, and plant habitat
- ✓ Project protects land containing shellfish
- ✓ Project remediates existing sources of pollution
- ✓ Project prevents pollution

Factors to Improve Output

- ✓ Incorporate nature-based solutions that may provide flood protection
- ✓ Incorporate nature-based solutions that may reduce storm damage
- ✓ Protect public water supply by reducing the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption
- ✓ Incorporate strategies that reduce carbon emissions
- ✓ Incorporate green infrastructure or nature-based solutions that recharge groundwater
- ✓ Incorporate green infrastructure to filter stormwater
- ✓ Incorporate nature-based solutions that sequester carbon carbon
- ✓ Incorporate vegetation that provides pollinator habitat
- ✓ Provide opportunities for passive and/or active recreation through open space
- ✓ Increase plants, trees, and/or other vegetation to provide oxygen production
- ✓ Mitigate atmospheric greenhouse gas concentrations and other toxic air pollutants through nature-based solutions
- ✓ Incorporate education and/or protect cultural resources as part of your project

Is the primary purpose of this project ecological restoration?

No

Project Benefits

Provides flood protection through nature-based solutions	No
Reduces storm damage	No
Recharges groundwater	No
Protects public water supply	No
Filters stormwater using green infrastructure	No
Improves water quality	Yes
Promotes decarbonization	No
Enables carbon sequestration	No
Provides oxygen production	No
Improves air quality	No
Prevents pollution	Yes
Remediates existing sources of pollution	Yes
Protects fisheries, wildlife, and plant habitat	Yes
Protects land containing shellfish	Yes
Provides pollinator habitat	No
Provides recreation	No
Provides cultural resources/education	No

Project Climate Exposure

Is the primary purpose of this project ecological restoration?	No

Does the project site have a history of coastal flooding?	No
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	Unsure
Does the project site have a history of riverine flooding?	No
Does the project result in a net increase in impervious area of the site?	Unsure
Are existing trees being removed as part of the proposed project?	Unsure

Project Assets

Asset: LAKE DRIVE PUMP STATION
Asset Type: Typically Unoccupied
Asset Sub-Type: Pump Station - Sanitary
Construction Type: New Construction
Construction Year: 2032
Useful Life: 50

Identify the length of time the asset can be inaccessible/inoperable without significant consequences.
Building must be accessible/operable at all times, even during natural hazard event

Identify the geographic area directly affected by permanent loss or significant inoperability of the building/facility.
Impacts would be regional (more than one municipality and/or surrounding region)

Identify the population directly served that would be affected by the permanent loss of use or inoperability of the building/facility.
Greater than 10,000 people

Identify if the building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.

If the building/facility became inoperable for longer than acceptable in Question 1, how, if at all, would it be expected to impact people's health and safety?
Inoperability of the building/facility would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses

If there are hazardous materials in your building/facility, what are the extent of impacts related to spills/releases of these materials?
Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety (E.g. wastewater treatment plant; biohazard laboratory)

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts on other facilities, assets, and/or infrastructure?
Significant – Inoperability is likely to impact other facilities, assets, or buildings and will likely affect their ability to operate

If this building/facility was damaged beyond repair, how much would it approximately cost to replace?
Between $10 million and $30 million

Is this a recreational facility which can be vacated during a natural hazard event?
No

If the building/facility became inoperable for longer than acceptable in Question 1, what are the public and/or social services impacts?
No alternative programs and/or services are available to support the community

If the building/facility became inoperable for longer than acceptable in Question 1, what are the environmental impacts related to natural resources?
Impact on natural resources will require remediation/rehabilitation

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to government services (i.e. the building is not able to serve or operate its intended users or function)?
Loss of building may reduce the ability to maintain some government services, while a majority of services will still exist.

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to loss of confidence in government (i.e. the building is not able to serve or operate its intended users or function)?
Loss of confidence in government agency

Report Comments

N/A

Climate Resilience Design Standards Tool Project Report

ORLEANS- INDIAN FORT HILL LANE PUMP STATION

Date Created: 11/16/2023 1:44:52 PM
Created By: Nickgolben1
Date Report Generated: 11/20/2023 4:54:59 PM
Tool Version: Version 1.2
Project Contact Information: Nick Golben (nick.golben@aecom.com)

Project Summary

Link to Project

Estimated Capital Cost: $5000000.00
End of Useful Life Year: 2091
Project within mapped Environmental Justice neighborhood: No

Ecosystem Service Benefits	Scores
Project Score	Low
Exposure	**Scores**
Sea Level Rise/Storm Surge	Not Exposed
Extreme Precipitation - Urban Flooding	Moderate Exposure
Extreme Precipitation - Riverine Flooding	High Exposure
Extreme Heat	Moderate Exposure



Asset Preliminary Climate Risk Rating Summary

Number of Assets: 1

Asset Risk	Sea Level Rise/Storm Surge	Extreme Precipitation - Urban Flooding	Extreme Precipitation - Riverine Flooding	Extreme Heat
INDIAN FORT HILL LANE PUMP STATION	Low Risk	High Risk	High Risk	High Risk

Climate Resilience Design Standards Summary

	Target Planning Horizon	Intermediate Planning Horizon	Percentile	Return Period	Tier
Sea Level Rise/Storm Surge					
INDIAN FORT HILL LANE PUMP STATION					
Extreme Precipitation					
INDIAN FORT HILL LANE PUMP STATION	2070			50-yr (2%)	Tier 3
Extreme Heat					
INDIAN FORT HILL LANE PUMP STATION	2070		90th		Tier 3

Scoring Rationale - Project Exposure Score

The purpose of the Exposure Score output is to provide a preliminary assessment of whether the overall project site and subsequent assets are exposed to impacts of natural hazard events and/or future impacts of climate change. For each climate parameter, the Tool will calculate one of the following exposure ratings: Not Exposed, Low Exposure, Moderate Exposure, or High Exposure. The rationale behind the exposure rating is provided below.

Sea Level Rise/Storm Surge

This project received a "Not Exposed" because of the following:

- Not located within the predicted mean high water shoreline by 2030
- No historic coastal flooding at project site
- Not located within the Massachusetts Coast Flood Risk Model (MC-FRM)

Extreme Precipitation - Urban Flooding

This project received a "Moderate Exposure" because of the following:

- Maximum annual daily rainfall exceeds 10 inches within the overall project's useful life
- No historic flooding at project site
- No increase to impervious area
- Existing impervious area of the project site is less than 10%

Extreme Precipitation - Riverine Flooding

This project received a "High Exposure" because of the following:

- Part of the project is within a mapped FEMA floodplain, outside of the Massachusetts Coast Flood Risk Model (MC-FRM)
- No historic riverine flooding at project site
- Project is more than 500ft from a waterbody
- Project is not likely susceptible to riverine erosion

Extreme Heat

This project received a "Moderate Exposure" because of the following:

- Existing impervious area of the project site is less than 10%
- 10 to 30 day increase in days over 90 deg. F within project's useful life
- Located within 100 ft of existing water body
- No increase to the impervious area of the project site
- No tree removal

Scoring Rationale - Asset Preliminary Climate Risk Rating

A Preliminary Climate Risk Rating is determined for each infrastructure and building asset by considering the overall project Exposure Score and responses to Step 4 questions provided by the user in the Tool. Natural Resource assets do not receive a risk rating. The following factors are what influenced the risk ratings for each asset.

Asset - INDIAN FORT HILL LANE PUMP STATION
Primary asset criticality factors influencing risk ratings for this asset:

- Asset must be operable at all times, even during natural hazard event
- Greater than 10,000 people would be directly affected by the loss/inoperability of the asset
- The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
- Inoperability of the asset would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses
- Inoperability is likely to significantly impact other facilities, assets, or buildings and will likely affect their ability to operate
- Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety

Project Climate Resilience Design Standards Output

Climate Resilience Design Standards and Guidance are recommended for each asset and climate parameter. The Design Standards for each climate parameter include the following: recommended planning horizon (target and/or intermediate), recommended return period (Sea Level Rise/Storm Surge and Precipitation) or percentile (Heat), and a list of applicable design criteria that are likely to be affected by climate change. Some design criteria have numerical values associated with the recommended return period and planning horizon, while others have tiered methodologies with step-by-step instructions on how to estimate design values given the other recommended design standards.

Asset: INDIAN FORT HILL LANE PUMP STATION — Building/Facility

Sea Level Rise/Storm Surge — Low Risk

Applicable Design Criteria

Projected Tidal Datums: NOT APPLICABLE

Projected Water Surface Elevation: NOT APPLICABLE

Projected Wave Action Water Elevation: NOT APPLICABLE

Projected Wave Heights: NOT APPLICABLE

Projected Duration of Flooding: NOT APPLICABLE

Projected Design Flood Velocity: NOT APPLICABLE

Projected Scour & Erosion: NOT APPLICABLE

Extreme Precipitation — High Risk

Target Planning Horizon: 2070
Return Period: 50-yr (2%)

LIMITATIONS: The recommended Standards for Total Precipitation Depth & Peak Intensity are determined by the user drawn polygon and relationships as defined in the Supporting Documents. The projected Total Precipitation Depth values provided through the Tool are based on the climate projections developed by Cornell University as part of EEA's Massachusetts Climate and Hydrologic Risk Project, GIS-based data as of 10/15/21. For additional information on the methodology of these precipitation outputs, see Supporting Documents.

While Total Precipitation Depth & Peak Intensity for 24-hour Design Storms are useful to inform planning and design, it is recommended to also consider additional longer- and shorter-duration precipitation events and intensities in accordance with best practices. Longer-duration, lower-intensity storms allow time for infiltration and reduce the load on infrastructure over the duration of the storm. Shorter-duration, higher-intensity storms often have higher runoff volumes because the water does not have enough time to infiltrate infrastructure systems (e.g., catch basins) and may overflow or back up during such storms, resulting in flooding. In the Northeast, short-duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. While the Tool does not provide recommended design standards for these scenarios, users should still consider both short- and long-duration precipitation events and how they may impact the asset.

The projected values, standards, and guidance provided within this Tool may be used to inform plans and designs, but they do not provide guarantees for future conditions or resilience. The projected values are not to be considered final or appropriate for construction documents without supporting engineering analyses. The guidance provided within this Tool is intended to be general and users are encouraged to do their own due diligence

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
INDIAN FORT HILL LANE PUMP STATION	2070	50-Year (2%)	8.2	Downloadable Methodology PDF

Projected Riverine Peak Discharge & Peak Flood Elevation: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Extreme Heat High Risk

Target Planning Horizon: 2070
Percentile: 90th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Annual/Summer/Winter Average Temperatures: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Heat Index: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Growing Degree Days: NOT APPLICABLE

Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Number of Heat Waves Per Year & Average Heat Wave Duration: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Cooling Degree Days & Heating Degree Days (base = 65°F): APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Project Inputs

Core Project Information

Name:	ORLEANS- INDIAN FORT HILL LANE PUMP STATION
Given the expected useful life of the project, through what year do you estimate the project to last (i.e. before a major reconstruction/renovation)?	2091
Location of Project:	Orleans
Estimated Capital Cost:	$5,000,000
Who is the Submitting Entity?	Private Other AECOM Nick Golben (nick.golben@aecom.com)
Is this project being submitted as part of a state grant application?	No
Which grant program?	
What stage are you in your project lifecycle?	Pre-Planning
Is climate resiliency a core objective of this project?	Yes
Is this project being submitted as part of the state capital planning process?	No
Is this project being submitted as part of a regulatory review process or permitting?	Yes
Brief Project Description:	Identify risk considerations when planning, designing, and constructing wastewater infrastructure that will improve water quality in Orleans.
Project Submission Comments:	

Project Ecosystem Service Benefits

Factors Influencing Output

- ✓ Project improves water quality
- ✓ Project protects fisheries, wildlife, and plant habitat
- ✓ Project protects land containing shellfish
- ✓ Project remediates existing sources of pollution
- ✓ Project prevents pollution

Factors to Improve Output

- ✓ Incorporate nature-based solutions that may provide flood protection
- ✓ Incorporate nature-based solutions that may reduce storm damage
- ✓ Protect public water supply by reducing the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption
- ✓ Incorporate strategies that reduce carbon emissions
- ✓ Incorporate green infrastructure or nature-based solutions that recharge groundwater
- ✓ Incorporate green infrastructure to filter stormwater
- ✓ Incorporate nature-based solutions that sequester carbon carbon
- ✓ Incorporate vegetation that provides pollinator habitat
- ✓ Provide opportunities for passive and/or active recreation through open space
- ✓ Increase plants, trees, and/or other vegetation to provide oxygen production
- ✓ Mitigate atmospheric greenhouse gas concentrations and other toxic air pollutants through nature-based solutions
- ✓ Incorporate education and/or protect cultural resources as part of your project

Is the primary purpose of this project ecological restoration?

No

Project Benefits

Provides flood protection through nature-based solutions	No
Reduces storm damage	No
Recharges groundwater	No
Protects public water supply	No
Filters stormwater using green infrastructure	No
Improves water quality	Yes
Promotes decarbonization	No
Enables carbon sequestration	No
Provides oxygen production	No
Improves air quality	No
Prevents pollution	Yes
Remediates existing sources of pollution	Yes
Protects fisheries, wildlife, and plant habitat	Yes
Protects land containing shellfish	Yes
Provides pollinator habitat	No
Provides recreation	No
Provides cultural resources/education	No

Project Climate Exposure

Is the primary purpose of this project ecological restoration?	No

Does the project site have a history of coastal flooding?	No
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	Unsure
Does the project site have a history of riverine flooding?	No
Does the project result in a net increase in impervious area of the site?	Unsure
Are existing trees being removed as part of the proposed project?	Unsure

Project Assets

Asset: INDIAN FORT HILL LANE PUMP STATION
Asset Type: Typically Unoccupied
Asset Sub-Type: Pump Station - Sanitary
Construction Type: New Construction
Construction Year: 2041
Useful Life: 50

Identify the length of time the asset can be inaccessible/inoperable without significant consequences.
Building must be accessible/operable at all times, even during natural hazard event

Identify the geographic area directly affected by permanent loss or significant inoperability of the building/facility.
Impacts would be regional (more than one municipality and/or surrounding region)

Identify the population directly served that would be affected by the permanent loss of use or inoperability of the building/facility.
Greater than 10,000 people

Identify if the building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.

If the building/facility became inoperable for longer than acceptable in Question 1, how, if at all, would it be expected to impact people's health and safety?
Inoperability of the building/facility would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses

If there are hazardous materials in your building/facility, what are the extent of impacts related to spills/releases of these materials?
Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety (E.g. wastewater treatment plant; biohazard laboratory)

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts on other facilities, assets, and/or infrastructure?
Significant – Inoperability is likely to impact other facilities, assets, or buildings and will likely affect their ability to operate

If this building/facility was damaged beyond repair, how much would it approximately cost to replace?
Between $10 million and $30 million

Is this a recreational facility which can be vacated during a natural hazard event?
No

If the building/facility became inoperable for longer than acceptable in Question 1, what are the public and/or social services impacts?
No alternative programs and/or services are available to support the community

If the building/facility became inoperable for longer than acceptable in Question 1, what are the environmental impacts related to natural resources?
Impact on natural resources will require remediation/rehabilitation

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to government services (i.e. the building is not able to serve or operate its intended users or function)?
Loss of building may reduce the ability to maintain some government services, while a majority of services will still exist.

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to loss of confidence in government (i.e. the building is not able to serve or operate its intended users or function)?
Loss of confidence in government agency

Report Comments

N/A

Climate Resilience Design Standards Tool Project Report

ORLEANS- HARWICH ROAD PUMP STATION

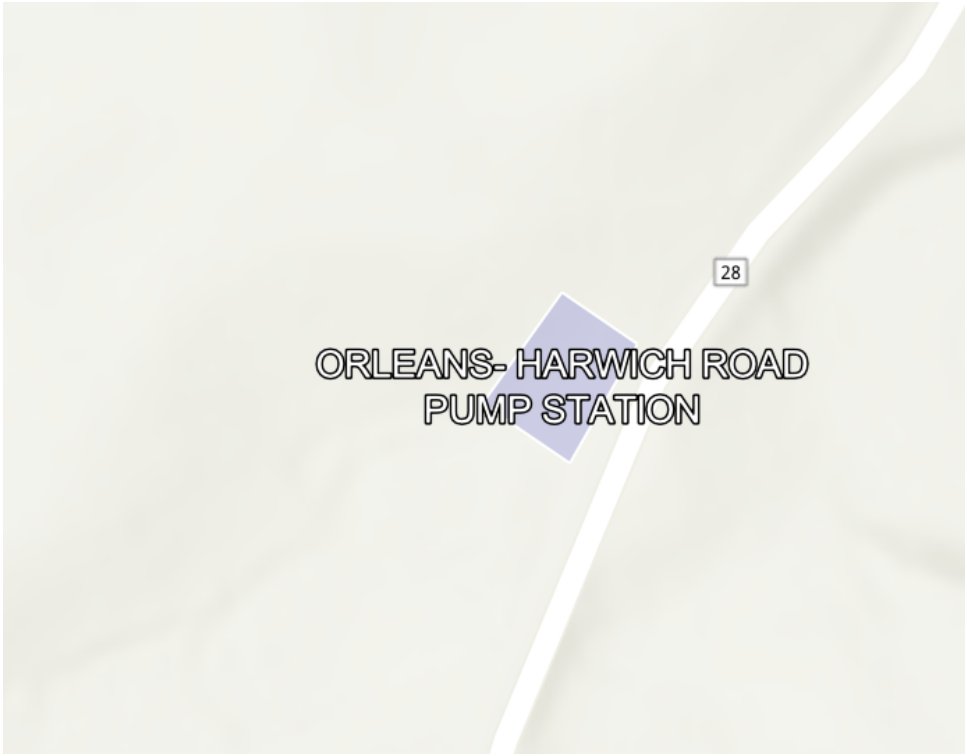
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Created By: Nickgolben1
Date Report Generated: 11/20/2023 4:53:37 PM
Tool Version: Version 1.2
Project Contact Information: Nick Golben (nick.golben@aecom.com)

Project Summary

Link to Project

Estimated Capital Cost: $5000000.00
End of Useful Life Year: 2079
Project within mapped Environmental Justice neighborhood: No

Ecosystem Service Benefits	Scores
Project Score	Low
Exposure	**Scores**
Sea Level Rise/Storm Surge	Not Exposed
Extreme Precipitation - Urban Flooding	Moderate Exposure
Extreme Precipitation - Riverine Flooding	Not Exposed
Extreme Heat	Moderate Exposure



Asset Preliminary Climate Risk Rating Summary

Number of Assets: 1

Asset Risk	Sea Level Rise/Storm Surge	Extreme Precipitation - Urban Flooding	Extreme Precipitation - Riverine Flooding	Extreme Heat
Harwich Road Pump Station	Low Risk	High Risk	Low Risk	High Risk

Climate Resilience Design Standards Summary

	Target Planning Horizon	Intermediate Planning Horizon	Percentile	Return Period	Tier
Sea Level Rise/Storm Surge					
Harwich Road Pump Station					
Extreme Precipitation					
Harwich Road Pump Station	2070			50-yr (2%)	Tier 3
Extreme Heat					
Harwich Road Pump Station	2070		90th		Tier 3

Scoring Rationale - Project Exposure Score

The purpose of the Exposure Score output is to provide a preliminary assessment of whether the overall project site and subsequent assets are exposed to impacts of natural hazard events and/or future impacts of climate change. For each climate parameter, the Tool will calculate one of the following exposure ratings: Not Exposed, Low Exposure, Moderate Exposure, or High Exposure. The rationale behind the exposure rating is provided below.

Sea Level Rise/Storm Surge

This project received a "Not Exposed" because of the following:

- Not located within the predicted mean high water shoreline by 2030
- No historic coastal flooding at project site
- Not located within the Massachusetts Coast Flood Risk Model (MC-FRM)

Extreme Precipitation - Urban Flooding

This project received a "Moderate Exposure" because of the following:

- Maximum annual daily rainfall exceeds 10 inches within the overall project's useful life
- No historic flooding at project site
- No increase to impervious area
- Existing impervious area of the project site is less than 10%

Extreme Precipitation - Riverine Flooding

This project received a "Not Exposed" because of the following:

- No historic riverine flooding at project site
- The project is not within a mapped FEMA floodplain [outside of the Massachusetts Coast Flood Risk Model (MC-FRM)]
- Project is more than 500ft from a waterbody
- Project is not likely susceptible to riverine erosion

Extreme Heat

This project received a "Moderate Exposure" because of the following:

- Existing impervious area of the project site is less than 10%
- 10 to 30 day increase in days over 90 deg. F within project's useful life
- Located within 100 ft of existing water body
- No increase to the impervious area of the project site
- No tree removal

Scoring Rationale - Asset Preliminary Climate Risk Rating

A Preliminary Climate Risk Rating is determined for each infrastructure and building asset by considering the overall project Exposure Score and responses to Step 4 questions provided by the user in the Tool. Natural Resource assets do not receive a risk rating. The following factors are what influenced the risk ratings for each asset.

Asset - Harwich Road Pump Station
Primary asset criticality factors influencing risk ratings for this asset:

- Asset must be operable at all times, even during natural hazard event
- Greater than 10,000 people would be directly affected by the loss/inoperability of the asset
- The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
- Inoperability of the asset would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses
- Inoperability is likely to significantly impact other facilities, assets, or buildings and will likely affect their ability to operate
- Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety

Project Climate Resilience Design Standards Output

Climate Resilience Design Standards and Guidance are recommended for each asset and climate parameter. The Design Standards for each climate parameter include the following: recommended planning horizon (target and/or intermediate), recommended return period (Sea Level Rise/Storm Surge and Precipitation) or percentile (Heat), and a list of applicable design criteria that are likely to be affected by climate change. Some design criteria have numerical values associated with the recommended return period and planning horizon, while others have tiered methodologies with step-by-step instructions on how to estimate design values given the other recommended design standards.

Asset: Harwich Road Pump Station — Building/Facility

Sea Level Rise/Storm Surge — Low Risk

Applicable Design Criteria

Projected Tidal Datums: NOT APPLICABLE

Projected Water Surface Elevation: NOT APPLICABLE

Projected Wave Action Water Elevation: NOT APPLICABLE

Projected Wave Heights: NOT APPLICABLE

Projected Duration of Flooding: NOT APPLICABLE

Projected Design Flood Velocity: NOT APPLICABLE

Projected Scour & Erosion: NOT APPLICABLE

Extreme Precipitation — High Risk

Target Planning Horizon: 2070
Return Period: 50-yr (2%)

LIMITATIONS: The recommended Standards for Total Precipitation Depth & Peak Intensity are determined by the user drawn polygon and relationships as defined in the Supporting Documents. The projected Total Precipitation Depth values provided through the Tool are based on the climate projections developed by Cornell University as part of EEA's Massachusetts Climate and Hydrologic Risk Project, GIS-based data as of 10/15/21. For additional information on the methodology of these precipitation outputs, see Supporting Documents.

While Total Precipitation Depth & Peak Intensity for 24-hour Design Storms are useful to inform planning and design, it is recommended to also consider additional longer- and shorter-duration precipitation events and intensities in accordance with best practices. Longer-duration, lower-intensity storms allow time for infiltration and reduce the load on infrastructure over the duration of the storm. Shorter-duration, higher-intensity storms often have higher runoff volumes because the water does not have enough time to infiltrate infrastructure systems (e.g., catch basins) and may overflow or back up during such storms, resulting in flooding. In the Northeast, short-duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. While the Tool does not provide recommended design standards for these scenarios, users should still consider both short- and long-duration precipitation events and how they may impact the asset.

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Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
Harwich Road Pump Station	2070	50-Year (2%)	8.2	Downloadable Methodology PDF

Projected Riverine Peak Discharge & Peak Flood Elevation: NOT APPLICABLE

Extreme Heat — High Risk

Target Planning Horizon: 2070
Percentile: 90th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Annual/Summer/Winter Average Temperatures: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Heat Index: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Growing Degree Days: NOT APPLICABLE

Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Number of Heat Waves Per Year & Average Heat Wave Duration: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Cooling Degree Days & Heating Degree Days (base = 65°F): APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Project Inputs

Core Project Information

Name:	ORLEANS- HARWICH ROAD PUMP STATION
Given the expected useful life of the project, through what year do you estimate the project to last (i.e. before a major reconstruction/renovation)?	2079
Location of Project:	Orleans
Estimated Capital Cost:	$5,000,000
Who is the Submitting Entity?	Private Other AECOM Nick Golben (nick.golben@aecom.com)
Is this project being submitted as part of a state grant application?	No
Which grant program?	
What stage are you in your project lifecycle?	Pre-Planning
Is climate resiliency a core objective of this project?	Yes
Is this project being submitted as part of the state capital planning process?	No
Is this project being submitted as part of a regulatory review process or permitting?	Yes
Brief Project Description:	Identify risk considerations when planning, designing, and constructing wastewater infrastructure that will improve water quality in Orleans.
Project Submission Comments:	

Project Ecosystem Service Benefits

Factors Influencing Output

- ✓ Project improves water quality
- ✓ Project protects fisheries, wildlife, and plant habitat
- ✓ Project protects land containing shellfish
- ✓ Project remediates existing sources of pollution
- ✓ Project prevents pollution

Factors to Improve Output

- ✓ Incorporate nature-based solutions that may provide flood protection
- ✓ Incorporate nature-based solutions that may reduce storm damage
- ✓ Protect public water supply by reducing the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption
- ✓ Incorporate strategies that reduce carbon emissions
- ✓ Incorporate green infrastructure or nature-based solutions that recharge groundwater
- ✓ Incorporate green infrastructure to filter stormwater
- ✓ Incorporate nature-based solutions that sequester carbon carbon
- ✓ Incorporate vegetation that provides pollinator habitat
- ✓ Provide opportunities for passive and/or active recreation through open space
- ✓ Increase plants, trees, and/or other vegetation to provide oxygen production
- ✓ Mitigate atmospheric greenhouse gas concentrations and other toxic air pollutants through nature-based solutions
- ✓ Incorporate education and/or protect cultural resources as part of your project

Is the primary purpose of this project ecological restoration?

No

Project Benefits

Provides flood protection through nature-based solutions	No
Reduces storm damage	No
Recharges groundwater	No
Protects public water supply	No
Filters stormwater using green infrastructure	No
Improves water quality	Yes
Promotes decarbonization	No
Enables carbon sequestration	No
Provides oxygen production	No
Improves air quality	No
Prevents pollution	Yes
Remediates existing sources of pollution	Yes
Protects fisheries, wildlife, and plant habitat	Yes
Protects land containing shellfish	Yes
Provides pollinator habitat	No
Provides recreation	No
Provides cultural resources/education	No

Project Climate Exposure

Is the primary purpose of this project ecological restoration?	No

Does the project site have a history of coastal flooding?	No
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	Unsure
Does the project site have a history of riverine flooding?	No
Does the project result in a net increase in impervious area of the site?	Unsure
Are existing trees being removed as part of the proposed project?	Unsure

Project Assets

Asset: Harwich Road Pump Station
Asset Type: Typically Unoccupied
Asset Sub-Type: Pump Station - Sanitary
Construction Type: New Construction
Construction Year: 2029
Useful Life: 50

Identify the length of time the asset can be inaccessible/inoperable without significant consequences.
Building must be accessible/operable at all times, even during natural hazard event

Identify the geographic area directly affected by permanent loss or significant inoperability of the building/facility.
Impacts would be regional (more than one municipality and/or surrounding region)

Identify the population directly served that would be affected by the permanent loss of use or inoperability of the building/facility.
Greater than 10,000 people

Identify if the building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.

If the building/facility became inoperable for longer than acceptable in Question 1, how, if at all, would it be expected to impact people's health and safety?
Inoperability of the building/facility would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses

If there are hazardous materials in your building/facility, what are the extent of impacts related to spills/releases of these materials?
Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety (E.g. wastewater treatment plant; biohazard laboratory)

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts on other facilities, assets, and/or infrastructure?
Significant – Inoperability is likely to impact other facilities, assets, or buildings and will likely affect their ability to operate

If this building/facility was damaged beyond repair, how much would it approximately cost to replace?
Between $10 million and $30 million

Is this a recreational facility which can be vacated during a natural hazard event?
No

If the building/facility became inoperable for longer than acceptable in Question 1, what are the public and/or social services impacts?
No alternative programs and/or services are available to support the community

If the building/facility became inoperable for longer than acceptable in Question 1, what are the environmental impacts related to natural resources?
Impact on natural resources will require remediation/rehabilitation

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to government services (i.e. the building is not able to serve or operate its intended users or function)?
Loss of building may reduce the ability to maintain some government services, while a majority of services will still exist.

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to loss of confidence in government (i.e. the building is not able to serve or operate its intended users or function)?
Loss of confidence in government agency

Report Comments

N/A

Climate Resilience Design Standards Tool Project Report

ORLEANS- GREAT OAK ROAD PUMP STATION

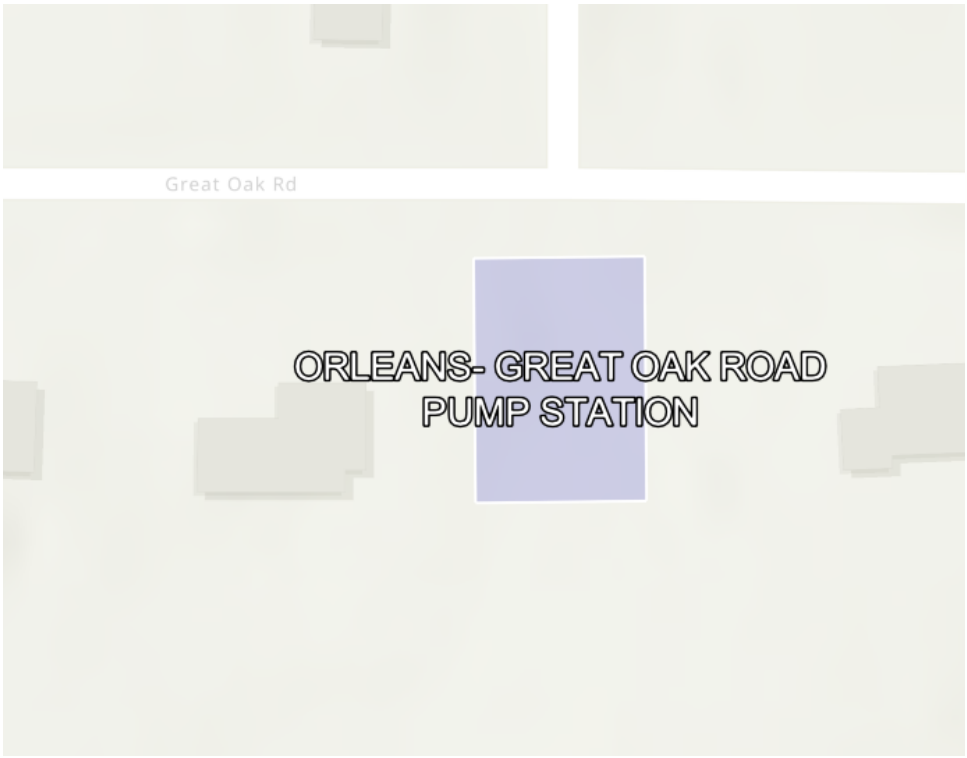
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Created By: Nickgolben1
Date Report Generated: 11/20/2023 4:56:17 PM
Tool Version: Version 1.2
Project Contact Information: Nick Golben (nick.golben@aecom.com)

Project Summary

Link to Project

Estimated Capital Cost: $5000000.00
End of Useful Life Year: 2100
Project within mapped Environmental Justice neighborhood: No

Ecosystem Service Benefits	Scores
Project Score	Low
Exposure	**Scores**
Sea Level Rise/Storm Surge	Not Exposed
Extreme Precipitation - Urban Flooding	Moderate Exposure
Extreme Precipitation - Riverine Flooding	Not Exposed
Extreme Heat	Moderate Exposure



Asset Preliminary Climate Risk Rating Summary

Number of Assets: 1

Asset Risk	Sea Level Rise/Storm Surge	Extreme Precipitation - Urban Flooding	Extreme Precipitation - Riverine Flooding	Extreme Heat
GREAT OAK ROAD PUMP STATION	Low Risk	High Risk	Low Risk	High Risk

Climate Resilience Design Standards Summary

	Target Planning Horizon	Intermediate Planning Horizon	Percentile	Return Period	Tier
Sea Level Rise/Storm Surge					
GREAT OAK ROAD PUMP STATION					
Extreme Precipitation					
GREAT OAK ROAD PUMP STATION	2070			50-yr (2%)	Tier 3
Extreme Heat					
GREAT OAK ROAD PUMP STATION	2070		90th		Tier 3

Scoring Rationale - Project Exposure Score

The purpose of the Exposure Score output is to provide a preliminary assessment of whether the overall project site and subsequent assets are exposed to impacts of natural hazard events and/or future impacts of climate change. For each climate parameter, the Tool will calculate one of the following exposure ratings: Not Exposed, Low Exposure, Moderate Exposure, or High Exposure. The rationale behind the exposure rating is provided below.

Sea Level Rise/Storm Surge

This project received a "Not Exposed" because of the following:

- Not located within the predicted mean high water shoreline by 2030
- No historic coastal flooding at project site
- Not located within the Massachusetts Coast Flood Risk Model (MC-FRM)

Extreme Precipitation - Urban Flooding

This project received a "Moderate Exposure" because of the following:

- Maximum annual daily rainfall exceeds 10 inches within the overall project's useful life
- No historic flooding at project site
- No increase to impervious area
- Existing impervious area of the project site is less than 10%

Extreme Precipitation - Riverine Flooding

This project received a "Not Exposed" because of the following:

- No historic riverine flooding at project site
- The project is not within a mapped FEMA floodplain [outside of the Massachusetts Coast Flood Risk Model (MC-FRM)]
- Project is more than 500ft from a waterbody
- Project is not likely susceptible to riverine erosion

Extreme Heat

This project received a "Moderate Exposure" because of the following:

- Not located within 100 ft of existing water body
- Existing impervious area of the project site is less than 10%
- 10 to 30 day increase in days over 90 deg. F within project's useful life
- No increase to the impervious area of the project site
- No tree removal

Scoring Rationale - Asset Preliminary Climate Risk Rating

A Preliminary Climate Risk Rating is determined for each infrastructure and building asset by considering the overall project Exposure Score and responses to Step 4 questions provided by the user in the Tool. Natural Resource assets do not receive a risk rating. The following factors are what influenced the risk ratings for each asset.

Asset - GREAT OAK ROAD PUMP STATION
Primary asset criticality factors influencing risk ratings for this asset:

- Asset must be operable at all times, even during natural hazard event
- Greater than 10,000 people would be directly affected by the loss/inoperability of the asset
- The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
- Inoperability of the asset would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses
- Inoperability is likely to significantly impact other facilities, assets, or buildings and will likely affect their ability to operate
- Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety

Project Climate Resilience Design Standards Output

Climate Resilience Design Standards and Guidance are recommended for each asset and climate parameter. The Design Standards for each climate parameter include the following: recommended planning horizon (target and/or intermediate), recommended return period (Sea Level Rise/Storm Surge and Precipitation) or percentile (Heat), and a list of applicable design criteria that are likely to be affected by climate change. Some design criteria have numerical values associated with the recommended return period and planning horizon, while others have tiered methodologies with step-by-step instructions on how to estimate design values given the other recommended design standards.

Asset: GREAT OAK ROAD PUMP STATION — Building/Facility

Sea Level Rise/Storm Surge — Low Risk

Applicable Design Criteria

Projected Tidal Datums: NOT APPLICABLE

Projected Water Surface Elevation: NOT APPLICABLE

Projected Wave Action Water Elevation: NOT APPLICABLE

Projected Wave Heights: NOT APPLICABLE

Projected Duration of Flooding: NOT APPLICABLE

Projected Design Flood Velocity: NOT APPLICABLE

Projected Scour & Erosion: NOT APPLICABLE

Extreme Precipitation — High Risk

Target Planning Horizon: 2070
Return Period: 50-yr (2%)

LIMITATIONS: The recommended Standards for Total Precipitation Depth & Peak Intensity are determined by the user drawn polygon and relationships as defined in the Supporting Documents. The projected Total Precipitation Depth values provided through the Tool are based on the climate projections developed by Cornell University as part of EEA's Massachusetts Climate and Hydrologic Risk Project, GIS-based data as of 10/15/21. For additional information on the methodology of these precipitation outputs, see Supporting Documents.

While Total Precipitation Depth & Peak Intensity for 24-hour Design Storms are useful to inform planning and design, it is recommended to also consider additional longer- and shorter-duration precipitation events and intensities in accordance with best practices. Longer-duration, lower-intensity storms allow time for infiltration and reduce the load on infrastructure over the duration of the storm. Shorter-duration, higher-intensity storms often have higher runoff volumes because the water does not have enough time to infiltrate infrastructure systems (e.g., catch basins) and may overflow or back up during such storms, resulting in flooding. In the Northeast, short-duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. While the Tool does not provide recommended design standards for these scenarios, users should still consider both short- and long-duration precipitation events and how they may impact the asset.

The projected values, standards, and guidance provided within this Tool may be used to inform plans and designs, but they do not provide guarantees for future conditions or resilience. The projected values are not to be considered final or appropriate for construction documents without supporting engineering analyses. The guidance provided within this Tool is intended to be general and users are encouraged to do their own due diligence

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
GREAT OAK ROAD PUMP STATION	2070	50-Year (2%)	8.2	Downloadable Methodology PDF

Projected Riverine Peak Discharge & Peak Flood Elevation: NOT APPLICABLE

Extreme Heat — High Risk

Target Planning Horizon: 2070
Percentile: 90th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Annual/Summer/Winter Average Temperatures: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Heat Index: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Growing Degree Days: NOT APPLICABLE

Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Number of Heat Waves Per Year & Average Heat Wave Duration: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Cooling Degree Days & Heating Degree Days (base = 65°F): APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Project Inputs

Core Project Information

Name:	ORLEANS- GREAT OAK ROAD PUMP STATION
Given the expected useful life of the project, through what year do you estimate the project to last (i.e. before a major reconstruction/renovation)?	2100
Location of Project:	Orleans
Estimated Capital Cost:	$5,000,000
Who is the Submitting Entity?	Private Other AECOM Nick Golben (nick.golben@aecom.com)
Is this project being submitted as part of a state grant application?	No
Which grant program?	
What stage are you in your project lifecycle?	Pre-Planning
Is climate resiliency a core objective of this project?	Yes
Is this project being submitted as part of the state capital planning process?	No
Is this project being submitted as part of a regulatory review process or permitting?	Yes
Brief Project Description:	Identify risk considerations when planning, designing, and constructing wastewater infrastructure that will improve water quality in Orleans.
Project Submission Comments:	

Project Ecosystem Service Benefits

Factors Influencing Output

- ✓ Project filters stormwater using green infrastructure
- ✓ Project protects fisheries, wildlife, and plant habitat
- ✓ Project protects land containing shellfish
- ✓ Project remediates existing sources of pollution
- ✓ Project prevents pollution

Factors to Improve Output

- ✓ Incorporate nature-based solutions that may provide flood protection
- ✓ Incorporate nature-based solutions that may reduce storm damage
- ✓ Protect public water supply by reducing the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption
- ✓ Incorporate strategies that reduce carbon emissions
- ✓ Incorporate green infrastructure or nature-based solutions that recharge groundwater
- ✓ Incorporate nature-based solutions that improve water quality
- ✓ Incorporate nature-based solutions that sequester carbon carbon
- ✓ Incorporate vegetation that provides pollinator habitat
- ✓ Provide opportunities for passive and/or active recreation through open space
- ✓ Increase plants, trees, and/or other vegetation to provide oxygen production
- ✓ Mitigate atmospheric greenhouse gas concentrations and other toxic air pollutants through nature-based solutions
- ✓ Incorporate education and/or protect cultural resources as part of your project

Is the primary purpose of this project ecological restoration?

No

Project Benefits

Provides flood protection through nature-based solutions	No
Reduces storm damage	No
Recharges groundwater	No
Protects public water supply	No
Filters stormwater using green infrastructure	Yes
Improves water quality	No
Promotes decarbonization	No
Enables carbon sequestration	No
Provides oxygen production	No
Improves air quality	No
Prevents pollution	Yes
Remediates existing sources of pollution	Yes
Protects fisheries, wildlife, and plant habitat	Yes
Protects land containing shellfish	Yes
Provides pollinator habitat	No
Provides recreation	No
Provides cultural resources/education	No

Project Climate Exposure

Is the primary purpose of this project ecological restoration?	No

Does the project site have a history of coastal flooding?	No
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	Unsure
Does the project site have a history of riverine flooding?	No
Does the project result in a net increase in impervious area of the site?	Unsure
Are existing trees being removed as part of the proposed project?	Unsure

Project Assets

Asset: GREAT OAK ROAD PUMP STATION
Asset Type: Typically Unoccupied
Asset Sub-Type: Pump Station - Sanitary
Construction Type: New Construction
Construction Year: 2050
Useful Life: 50

Identify the length of time the asset can be inaccessible/inoperable without significant consequences.
Building must be accessible/operable at all times, even during natural hazard event

Identify the geographic area directly affected by permanent loss or significant inoperability of the building/facility.
Impacts would be regional (more than one municipality and/or surrounding region)

Identify the population directly served that would be affected by the permanent loss of use or inoperability of the building/facility.
Greater than 10,000 people

Identify if the building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.

If the building/facility became inoperable for longer than acceptable in Question 1, how, if at all, would it be expected to impact people's health and safety?
Inoperability of the building/facility would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses

If there are hazardous materials in your building/facility, what are the extent of impacts related to spills/releases of these materials?
Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety (E.g. wastewater treatment plant; biohazard laboratory)

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts on other facilities, assets, and/or infrastructure?
Significant – Inoperability is likely to impact other facilities, assets, or buildings and will likely affect their ability to operate

If this building/facility was damaged beyond repair, how much would it approximately cost to replace?
Between $10 million and $30 million

Is this a recreational facility which can be vacated during a natural hazard event?
No

If the building/facility became inoperable for longer than acceptable in Question 1, what are the public and/or social services impacts?
No alternative programs and/or services are available to support the community

If the building/facility became inoperable for longer than acceptable in Question 1, what are the environmental impacts related to natural resources?
Impact on natural resources will require remediation/rehabilitation

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to government services (i.e. the building is not able to serve or operate its intended users or function)?
Loss of building may reduce the ability to maintain some government services, while a majority of services will still exist.

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to loss of confidence in government (i.e. the building is not able to serve or operate its intended users or function)?
Loss of confidence in government agency

Report Comments

N/A

Climate Resilience Design Standards Tool Project Report

ORLEANS- FOX RIDGE DRIVE PUMP STATION

Date Created: 11/16/2023 1:52:42 PM
Created By: Nickgolben1
Date Report Generated: 11/20/2023 4:55:35 PM
Tool Version: Version 1.2
Project Contact Information: Nick Golben (nick.golben@aecom.com)

Project Summary

Link to Project

Estimated Capital Cost: $5000000.00
End of Useful Life Year: 2094
Project within mapped Environmental Justice neighborhood: No

Ecosystem Service Benefits	Scores
Project Score	Low
Exposure	**Scores**
Sea Level Rise/Storm Surge	Moderate Exposure
Extreme Precipitation - Urban Flooding	Moderate Exposure
Extreme Precipitation - Riverine Flooding	Not Exposed
Extreme Heat	Moderate Exposure



Asset Preliminary Climate Risk Rating Summary

Number of Assets: 1

Asset Risk	Sea Level Rise/Storm Surge	Extreme Precipitation - Urban Flooding	Extreme Precipitation - Riverine Flooding	Extreme Heat
FOX RIDGE DRIVE PUMP STATION	High Risk	High Risk	Low Risk	High Risk

Climate Resilience Design Standards Summary

	Target Planning Horizon	Intermediate Planning Horizon	Percentile	Return Period	Tier
Sea Level Rise/Storm Surge					
FOX RIDGE DRIVE PUMP STATION	2070	2050		500-yr (0.2%)	
Extreme Precipitation					
FOX RIDGE DRIVE PUMP STATION	2070			50-yr (2%)	Tier 3
Extreme Heat					
FOX RIDGE DRIVE PUMP STATION	2070		90th		Tier 3

Scoring Rationale - Project Exposure Score

The purpose of the Exposure Score output is to provide a preliminary assessment of whether the overall project site and subsequent assets are exposed to impacts of natural hazard events and/or future impacts of climate change. For each climate parameter, the Tool will calculate one of the following exposure ratings: Not Exposed, Low Exposure, Moderate Exposure, or High Exposure. The rationale behind the exposure rating is provided below.

Sea Level Rise/Storm Surge

This project received a "Moderate Exposure" because of the following:

- Exposed to the 1% annual coastal flood event as early as 2030
- Located within the 0.1% annual coastal flood event within the project's useful life
- Not located within the predicted mean high water shoreline by 2030

Extreme Precipitation - Urban Flooding

This project received a "Moderate Exposure" because of the following:

- Maximum annual daily rainfall exceeds 10 inches within the overall project's useful life
- No historic flooding at project site
- No increase to impervious area
- Existing impervious area of the project site is less than 10%

Extreme Precipitation - Riverine Flooding

This project received a "Not Exposed" because of the following:

- No historic riverine flooding at project site
- The project is not within a mapped FEMA floodplain [outside of the Massachusetts Coast Flood Risk Model (MC-FRM)]
- Project is more than 500ft from a waterbody
- Project is not likely susceptible to riverine erosion

Extreme Heat

This project received a "Moderate Exposure" because of the following:

- Between 10% and 40% of the existing project site has canopy cover
- 10 to 30 day increase in days over 90 deg. F within project's useful life
- Located within 100 ft of existing water body
- No increase to the impervious area of the project site
- No tree removal

Scoring Rationale - Asset Preliminary Climate Risk Rating

A Preliminary Climate Risk Rating is determined for each infrastructure and building asset by considering the overall project Exposure Score and responses to Step 4 questions provided by the user in the Tool. Natural Resource assets do not receive a risk rating. The following factors are what influenced the risk ratings for each asset.

Asset - FOX RIDGE DRIVE PUMP STATION
Primary asset criticality factors influencing risk ratings for this asset:

- Asset must be operable at all times, even during natural hazard event
- Greater than 10,000 people would be directly affected by the loss/inoperability of the asset
- The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
- Inoperability of the asset would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses
- Inoperability is likely to significantly impact other facilities, assets, or buildings and will likely affect their ability to operate
- Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety

Project Climate Resilience Design Standards Output

Climate Resilience Design Standards and Guidance are recommended for each asset and climate parameter. The Design Standards for each climate parameter include the following: recommended planning horizon (target and/or intermediate), recommended return period (Sea Level Rise/Storm Surge and Precipitation) or percentile (Heat), and a list of applicable design criteria that are likely to be affected by climate change. Some design criteria have numerical values associated with the recommended return period and planning horizon, while others have tiered methodologies with step-by-step instructions on how to estimate design values given the other recommended design standards.

Asset: FOX RIDGE DRIVE PUMP STATION — Building/Facility

Sea Level Rise/Storm Surge — High Risk

Target Planning Horizon: 2070
Intermediate Planning Horizon: 2050
Return Period: 500-yr (0.2%)

LIMITATIONS: The recommended Climate Resilience Design Standards for the Sea Level Rise / Storm Surge Design Criteria are based on the user drawn polygon and relationships as defined in the Supporting Documents. The projected values provided through the Tool are based on the Massachusetts Coast Flood Risk Model (MC-FRM) outputs as of 9/13/2021, which included GIS-based data for three planning horizons (2030, 2050, 2070) and six return periods (0.1%, 0.2%, 0.5%, 1%, 2%, 5%). These values are projections based on assumptions as defined in the model and the LiDAR used at the time. For additional information on the MC-FRM, review the additional resources provided on the Start Here page.

The projected values, Standards, and Guidance provided within this Tool may be used to inform plans and designs, but they do not provide guarantees for future conditions or resilience. The projected values are not to be considered final or appropriate for construction documents without supporting engineering analyses. The guidance provided within this Tool is intended to be general and users are encouraged to do their own due diligence.

Applicable Design Criteria

Projected Tidal Datums: APPLICABLE
Note: The site is exposed to Sea Level Rise/Storm Surge, but projected Tidal Datums are not available within the site. Additional site-specific analyses are recommended to identify projected Tidal Datums for the recommended planning horizon. Consult a professional coastal engineer or modeler to estimate projected Tidal Datums based on the recommended Standards and additional outputs provided through this Tool.

Projected Water Surface Elevation: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period	Max	Min	Area Weighted Average
			(ft - NAVD88)		
FOX RIDGE DRIVE PUMP STATION	2050	0.2% (500-Year)	14.9	14.9	14.9
	2070		15.9	15.9	15.9

Projected Wave Action Water Elevation: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period	Max	Min	Area Weighted Average
			(ft - NAVD88)		
FOX RIDGE DRIVE PUMP STATION	2050	0.2% (500-Year)	14.9	14.9	14.9
	2070		15.9	15.9	15.9

Projected Wave Heights: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period	Max	Min	Area Weighted Average
			(Feet)		
FOX RIDGE DRIVE PUMP STATION	2050	0.2% (500-Year)	0.0	0.0	0.0
	2070		0.0	0.0	0.0

Projected Duration of Flooding: APPLICABLE
Methodology to Estimate Projected Values

Projected Design Flood Velocity: APPLICABLE
Methodology to Estimate Projected Values

Projected Scour & Erosion: NOT APPLICABLE

Extreme Precipitation — High Risk

Target Planning Horizon: 2070
Return Period: 50-yr (2%)

LIMITATIONS: The recommended Standards for Total Precipitation Depth & Peak Intensity are determined by the user drawn polygon and relationships as defined in the Supporting Documents. The projected Total Precipitation Depth values provided through the Tool are based on the climate projections developed by Cornell University as part of EEA's Massachusetts Climate and Hydrologic Risk Project, GIS-based data as of 10/15/21. For additional information on the methodology of these precipitation outputs, see Supporting Documents.

While Total Precipitation Depth & Peak Intensity for 24-hour Design Storms are useful to inform planning and design, it is recommended to also consider additional longer- and shorter-duration precipitation events and intensities in accordance with best practices. Longer-duration, lower-intensity storms allow time for infiltration and reduce the load on infrastructure over the duration of the storm. Shorter-duration, higher-intensity storms often have higher runoff volumes because the water does not have enough time to infiltrate infrastructure systems (e.g., catch basins) and may overflow or back up during such storms, resulting in flooding. In the Northeast, short-duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. While the Tool does not provide recommended design standards for these scenarios, users should still consider both short- and long-duration precipitation events and how they may impact the asset.

The projected values, standards, and guidance provided within this Tool may be used to inform plans and designs, but they do not provide guarantees for future conditions or resilience. The projected values are not to be considered final or appropriate for construction documents without supporting engineering analyses. The guidance provided within this Tool is intended to be general and users are encouraged to do their own due diligence

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
FOX RIDGE DRIVE PUMP STATION	2070	50-Year (2%)	8.2	Downloadable Methodology PDF

Projected Riverine Peak Discharge & Peak Flood Elevation: NOT APPLICABLE

Extreme Heat — High Risk

Target Planning Horizon: 2070
Percentile: 90th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Annual/Summer/Winter Average Temperatures: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Heat Index: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Growing Degree Days: NOT APPLICABLE

Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Number of Heat Waves Per Year & Average Heat Wave Duration: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Cooling Degree Days & Heating Degree Days (base = 65°F): APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Sea Level Rise/Storm Surge Project Maps

The following three maps illustrate the Projected Water Surface Elevation for the 2030, 2050, and 2070 planning horizons corresponding to the lowest return period (largest design storm) recommended across the assets identified for this project in the Tool. For projects that only have Natural Resource assets, the maps will show the Projected Water Surface Elevations corresponding to the 5% (20-year) return period. Refer to the Climate Resilience Design Standards Output - Sea Level Rise/Storm Surge Section for additional values associated with other assets. The maps include the project area as drawn by the user with a 0.1 mile minimum buffer, but do not reflect the location of specific assets on the site.

LIMITATIONS: The recommended Climate Resilience Design Standards for the Sea Level Rise / Storm Surge Design Criteria are based on the user drawn polygon and relationships as defined in the Supporting Documents. The projected values and maps provided through the Tool are based on the Massachusetts Coast Flood Risk Model (MC-FRM) outputs as of 9/13/2021, which included GIS-based data for three planning horizons (2030, 2050, 2070) and six return periods (0.1%, 0.2%, 0.5%, 1%, 2%, 5%). These values are projections based on assumptions as defined in the model and the LiDAR used at the time. For additional information on the MC-FRM, review the additional resources provided on the Start Here page.

The projected values, maps, Standards, and Guidance provided within this Tool may be used to inform plans and designs, but they do not provide guarantees for future conditions or resilience. The projected values are not to be considered final or appropriate for construction documents without supporting engineering analyses. The guidance provided within this Tool is intended to be general and users are encouraged to do their own due diligence.

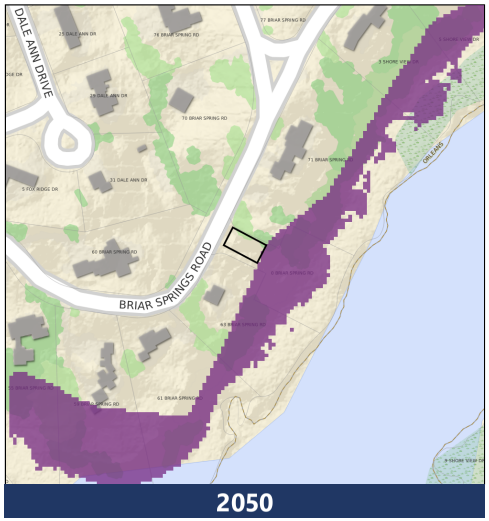
Legend

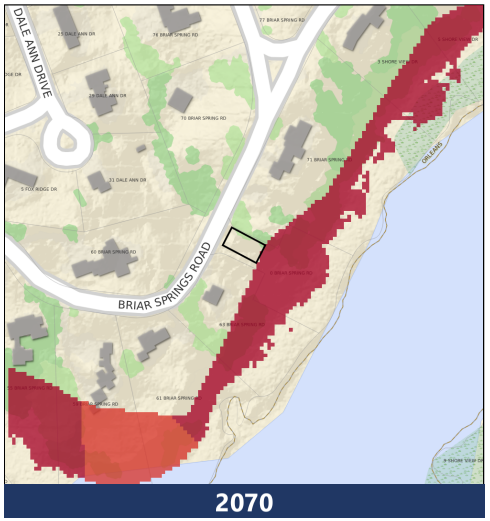
- Project Boundary

Projected Water Surface Elevation (ft-NAVD88)

- ≤ 13.7
- 13.7 - 13.8
- 13.8 - 13.9
- 13.9 - 14.0
- 14.0 - 14.1
- 14.1 - 14.2
- 14.2 - 14.3
- 14.3 - 14.4
- 14.4 - 14.5
- 14.5 - 14.6
- 14.6 - 14.7
- 14.7 - 14.8
- 14.8 - 14.9
- 14.9 - 15.0
- 15.0 - 15.1
- 15.1 - 15.2
- 15.2 - 15.3
- 15.3 - 15.4
- 15.4 - 15.5
- 15.5 - 15.6
- 15.6 - 15.7
- 15.7 - 15.8
- 15.8 - 15.9
- ≥ 15.9







Climate Resilience Design Standards Tool:
Sea Level Rise/Storm Surge Design Criteria
Projected Water Surface Elevation Map: 0.2% (500-yr)

Project Name: ORLEANS- FOX RIDGE DRIVE PUMP STATION
Location (Town): Orleans

0.25 0.5 1.0 Miles

Created by: Nickgolben1
Date Created: 11/16/2023
Tool Version: 1.3

N

Asset Name	Planning Horizon	Return Period	Max	Min	Area Weighted Average (ft-NAVD88)
FOX RIDGE DRIVE PUMP STATION	2030	0.2% (500-yr)	13.7	13.7	13.7
	2050	0.2% (500-yr)	14.9	14.9	14.9
	2070	0.2% (500-yr)	15.9	15.9	15.9



Climate Resilience Design Standards Tool:
Sea Level Rise/Storm Surge Design Criteria
Projected Water Surface Elevation Map: 2030, 0.2% (500-yr)

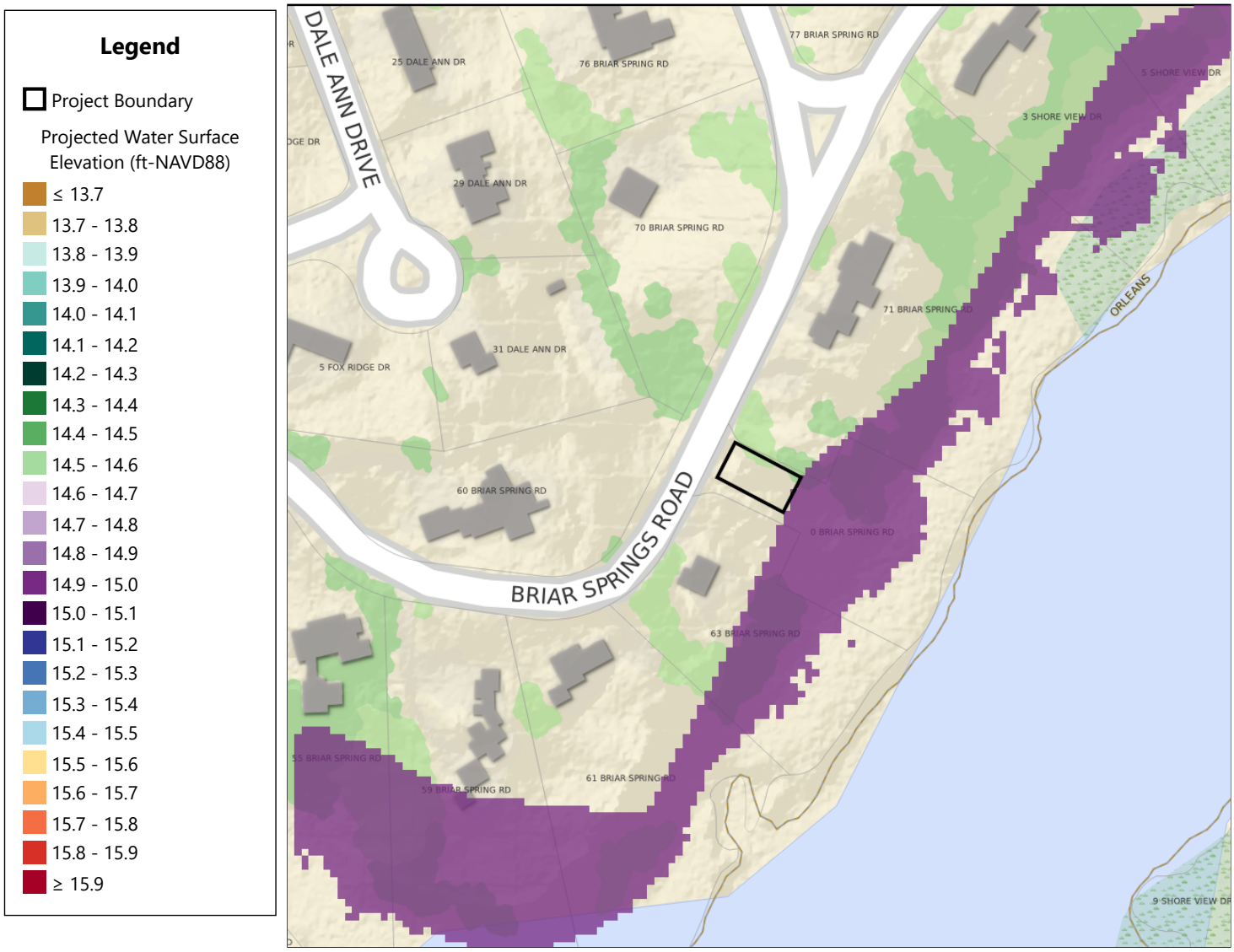
Project Name: ORLEANS- FOX RIDGE DRIVE PUMP STATION
Location (Town): Orleans

0.05 0.1 0.25 Miles

Created by: Nickgolben1
Date Created: 11/16/2023
Tool Version: 1.3

N

Asset Name	Planning Horizon	Return Period	Max	Min	Area Weighted Average (ft-NAVD88)
FOX RIDGE DRIVE PUMP STATION	2030	0.2% (500-yr)	13.7	13.7	13.7



Climate Resilience Design Standards Tool:
Sea Level Rise/Storm Surge Design Criteria
Projected Water Surface Elevation Map: 2050, 0.2% (500-yr)

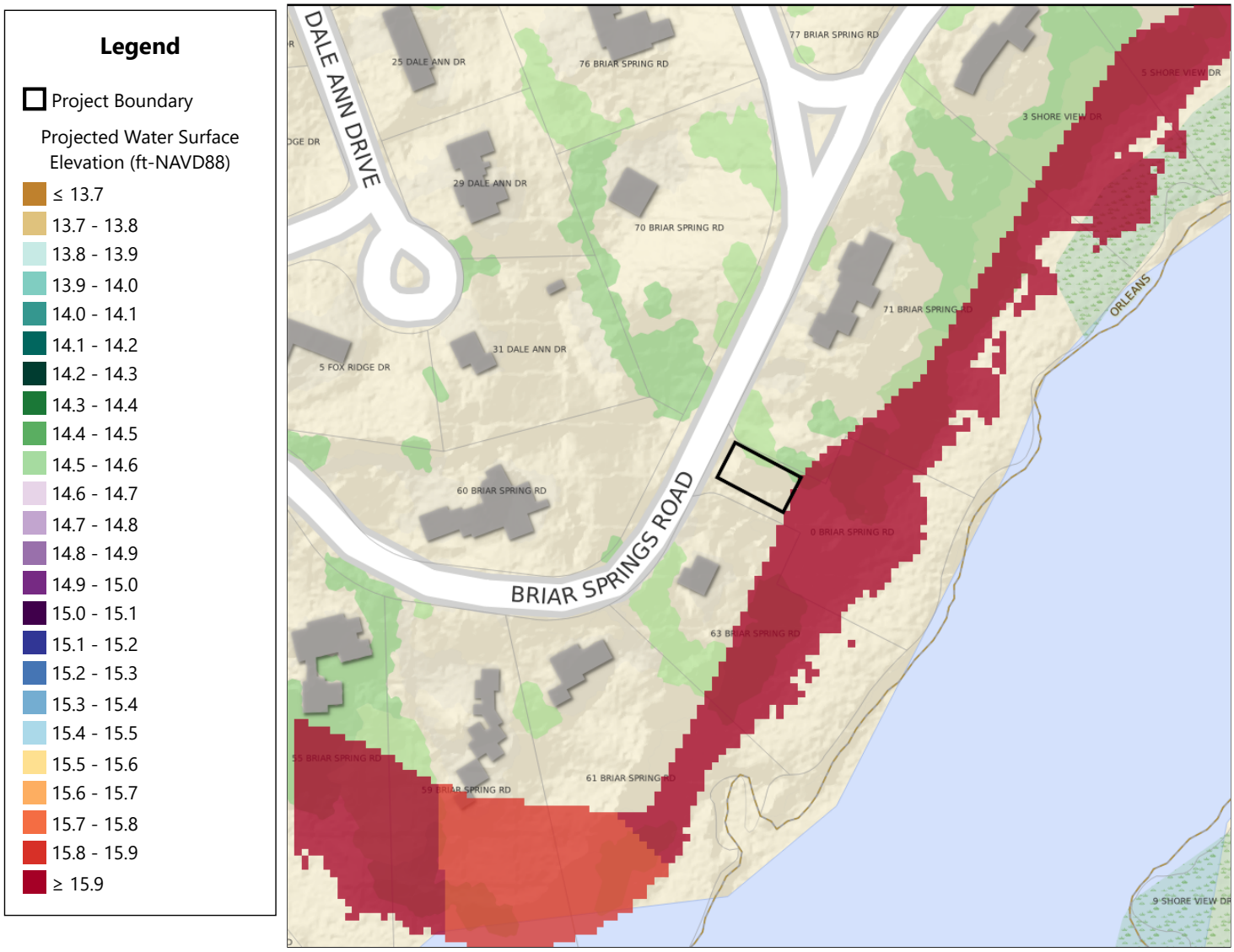
Project Name: ORLEANS- FOX RIDGE DRIVE PUMP STATION
Location (Town): Orleans

0.05 0.1 0.25 Miles

Created by: Nickgolben1
Date Created: 11/16/2023
Tool Version: 1.3

N

Asset Name	Planning Horizon	Return Period	Max	Min	Area Weighted Average (ft-NAVD88)
FOX RIDGE DRIVE PUMP STATION	2050	0.2% (500-yr)	14.9	14.9	14.9



Climate Resilience Design Standards Tool:
Sea Level Rise/Storm Surge Design Criteria
Projected Water Surface Elevation Map: 2070, 0.2% (500-yr)

Project Name: ORLEANS- FOX RIDGE DRIVE PUMP STATION
Location (Town): Orleans

0.05 0.1 0.25 Miles

Created by: Nickgolben1
Date Created: 11/16/2023
Tool Version: 1.3

N

Asset Name	Planning Horizon	Return Period	Max	Min	Area Weighted Average (ft-NAVD88)
FOX RIDGE DRIVE PUMP STATION	2070	0.2% (500-yr)	15.9	15.9	15.9

Project Inputs

Core Project Information

Name:	ORLEANS- FOX RIDGE DRIVE PUMP STATION
Given the expected useful life of the project, through what year do you estimate the project to last (i.e. before a major reconstruction/renovation)?	2094
Location of Project:	Orleans
Estimated Capital Cost:	$5,000,000
Who is the Submitting Entity?	Private Other AECOM Nick Golben (nick.golben@aecom.com)
Is this project being submitted as part of a state grant application?	No
Which grant program?	
What stage are you in your project lifecycle?	Pre-Planning
Is climate resiliency a core objective of this project?	Yes
Is this project being submitted as part of the state capital planning process?	No
Is this project being submitted as part of a regulatory review process or permitting?	Yes
Brief Project Description:	Identify risk considerations when planning, designing, and constructing wastewater infrastructure that will improve water quality in Orleans.
Project Submission Comments:	

Project Ecosystem Service Benefits

Factors Influencing Output

- ✓ Project improves water quality
- ✓ Project protects fisheries, wildlife, and plant habitat
- ✓ Project protects land containing shellfish
- ✓ Project remediates existing sources of pollution
- ✓ Project prevents pollution

Factors to Improve Output

- ✓ Incorporate nature-based solutions that may provide flood protection
- ✓ Incorporate nature-based solutions that may reduce storm damage
- ✓ Protect public water supply by reducing the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption
- ✓ Incorporate strategies that reduce carbon emissions
- ✓ Incorporate green infrastructure or nature-based solutions that recharge groundwater
- ✓ Incorporate green infrastructure to filter stormwater
- ✓ Incorporate nature-based solutions that sequester carbon carbon
- ✓ Incorporate vegetation that provides pollinator habitat
- ✓ Provide opportunities for passive and/or active recreation through open space
- ✓ Increase plants, trees, and/or other vegetation to provide oxygen production
- ✓ Mitigate atmospheric greenhouse gas concentrations and other toxic air pollutants through nature-based solutions
- ✓ Incorporate education and/or protect cultural resources as part of your project

Is the primary purpose of this project ecological restoration?

No

Project Benefits

Provides flood protection through nature-based solutions	No
Reduces storm damage	No
Recharges groundwater	No
Protects public water supply	No
Filters stormwater using green infrastructure	No
Improves water quality	Yes
Promotes decarbonization	No
Enables carbon sequestration	No
Provides oxygen production	No
Improves air quality	No
Prevents pollution	Yes
Remediates existing sources of pollution	Yes
Protects fisheries, wildlife, and plant habitat	Yes
Protects land containing shellfish	Yes
Provides pollinator habitat	No
Provides recreation	No
Provides cultural resources/education	No

Project Climate Exposure

Is the primary purpose of this project ecological restoration?	No

Does the project site have a history of coastal flooding?	No
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	Unsure
Does the project site have a history of riverine flooding?	No
Does the project result in a net increase in impervious area of the site?	Unsure
Are existing trees being removed as part of the proposed project?	Unsure

Project Assets

Asset: FOX RIDGE DRIVE PUMP STATION
Asset Type: Typically Unoccupied
Asset Sub-Type: Pump Station - Sanitary
Construction Type: New Construction
Construction Year: 2044
Useful Life: 50

Identify the length of time the asset can be inaccessible/inoperable without significant consequences.
Building must be accessible/operable at all times, even during natural hazard event

Identify the geographic area directly affected by permanent loss or significant inoperability of the building/facility.
Impacts would be regional (more than one municipality and/or surrounding region)

Identify the population directly served that would be affected by the permanent loss of use or inoperability of the building/facility.
Greater than 10,000 people

Identify if the building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.

If the building/facility became inoperable for longer than acceptable in Question 1, how, if at all, would it be expected to impact people's health and safety?
Inoperability of the building/facility would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses

If there are hazardous materials in your building/facility, what are the extent of impacts related to spills/releases of these materials?
Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety (E.g. wastewater treatment plant; biohazard laboratory)

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts on other facilities, assets, and/or infrastructure?
Significant – Inoperability is likely to impact other facilities, assets, or buildings and will likely affect their ability to operate

If this building/facility was damaged beyond repair, how much would it approximately cost to replace?
Between $10 million and $30 million

Is this a recreational facility which can be vacated during a natural hazard event?
No

If the building/facility became inoperable for longer than acceptable in Question 1, what are the public and/or social services impacts?
No alternative programs and/or services are available to support the community

If the building/facility became inoperable for longer than acceptable in Question 1, what are the environmental impacts related to natural resources?
Impact on natural resources will require remediation/rehabilitation

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to government services (i.e. the building is not able to serve or operate its intended users or function)?
Loss of building may reduce the ability to maintain some government services, while a majority of services will still exist.

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to loss of confidence in government (i.e. the building is not able to serve or operate its intended users or function)?
Loss of confidence in government agency

Report Comments

N/A

Climate Resilience Design Standards Tool Project Report

ORLEANS- FINLAY ROAD PUMP STATION

Date Created: 11/16/2023 12:44:26 PM
Created By: Nickgolben1
Date Report Generated: 11/20/2023 4:53:11 PM
Tool Version: Version 1.2
Project Contact Information: Nick Golben (nick.golben@aecom.com)

Project Summary

Link to Project

Estimated Capital Cost: $5000000.00
End of Useful Life Year: 2076
Project within mapped Environmental Justice neighborhood: No

Ecosystem Service Benefits	Scores
Project Score	Low
Exposure	**Scores**
Sea Level Rise/Storm Surge	Not Exposed
Extreme Precipitation - Urban Flooding	Moderate Exposure
Extreme Precipitation - Riverine Flooding	Not Exposed
Extreme Heat	High Exposure



Asset Preliminary Climate Risk Rating Summary

Number of Assets: 1

Asset Risk	Sea Level Rise/Storm Surge	Extreme Precipitation - Urban Flooding	Extreme Precipitation - Riverine Flooding	Extreme Heat
FINLAY ROAD PUMP STATION	Low Risk	High Risk	Low Risk	High Risk

Climate Resilience Design Standards Summary

	Target Planning Horizon	Intermediate Planning Horizon	Percentile	Return Period	Tier
Sea Level Rise/Storm Surge					
FINLAY ROAD PUMP STATION					
Extreme Precipitation					
FINLAY ROAD PUMP STATION	2070			50-yr (2%)	Tier 3
Extreme Heat					
FINLAY ROAD PUMP STATION	2070		90th		Tier 3

Scoring Rationale - Project Exposure Score

The purpose of the Exposure Score output is to provide a preliminary assessment of whether the overall project site and subsequent assets are exposed to impacts of natural hazard events and/or future impacts of climate change. For each climate parameter, the Tool will calculate one of the following exposure ratings: Not Exposed, Low Exposure, Moderate Exposure, or High Exposure. The rationale behind the exposure rating is provided below.

Sea Level Rise/Storm Surge

This project received a "Not Exposed" because of the following:

- Not located within the predicted mean high water shoreline by 2030
- No historic coastal flooding at project site
- Not located within the Massachusetts Coast Flood Risk Model (MC-FRM)

Extreme Precipitation - Urban Flooding

This project received a "Moderate Exposure" because of the following:

- Maximum annual daily rainfall exceeds 10 inches within the overall project's useful life
- No historic flooding at project site
- No increase to impervious area
- Existing impervious area of the project site is less than 10%

Extreme Precipitation - Riverine Flooding

This project received a "Not Exposed" because of the following:

- No historic riverine flooding at project site
- The project is not within a mapped FEMA floodplain [outside of the Massachusetts Coast Flood Risk Model (MC-FRM)]
- Project is more than 500ft from a waterbody
- Project is not likely susceptible to riverine erosion

Extreme Heat

This project received a "High Exposure" because of the following:

- Less than 10% of the existing project site has canopy cover
- 10 to 30 day increase in days over 90 deg. F within project's useful life
- Located within 100 ft of existing water body
- No increase to the impervious area of the project site
- No tree removal

Scoring Rationale - Asset Preliminary Climate Risk Rating

A Preliminary Climate Risk Rating is determined for each infrastructure and building asset by considering the overall project Exposure Score and responses to Step 4 questions provided by the user in the Tool. Natural Resource assets do not receive a risk rating. The following factors are what influenced the risk ratings for each asset.

Asset - FINLAY ROAD PUMP STATION
Primary asset criticality factors influencing risk ratings for this asset:

- Asset must be operable at all times, even during natural hazard event
- Greater than 10,000 people would be directly affected by the loss/inoperability of the asset
- The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
- Inoperability of the asset would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses
- Inoperability is likely to significantly impact other facilities, assets, or buildings and will likely affect their ability to operate
- Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety

Project Climate Resilience Design Standards Output

Climate Resilience Design Standards and Guidance are recommended for each asset and climate parameter. The Design Standards for each climate parameter include the following: recommended planning horizon (target and/or intermediate), recommended return period (Sea Level Rise/Storm Surge and Precipitation) or percentile (Heat), and a list of applicable design criteria that are likely to be affected by climate change. Some design criteria have numerical values associated with the recommended return period and planning horizon, while others have tiered methodologies with step-by-step instructions on how to estimate design values given the other recommended design standards.

Asset: FINLAY ROAD PUMP STATION — Building/Facility

Sea Level Rise/Storm Surge — Low Risk

Applicable Design Criteria

Projected Tidal Datums: NOT APPLICABLE

Projected Water Surface Elevation: NOT APPLICABLE

Projected Wave Action Water Elevation: NOT APPLICABLE

Projected Wave Heights: NOT APPLICABLE

Projected Duration of Flooding: NOT APPLICABLE

Projected Design Flood Velocity: NOT APPLICABLE

Projected Scour & Erosion: NOT APPLICABLE

Extreme Precipitation — High Risk

Target Planning Horizon: 2070
Return Period: 50-yr (2%)

LIMITATIONS: The recommended Standards for Total Precipitation Depth & Peak Intensity are determined by the user drawn polygon and relationships as defined in the Supporting Documents. The projected Total Precipitation Depth values provided through the Tool are based on the climate projections developed by Cornell University as part of EEA's Massachusetts Climate and Hydrologic Risk Project, GIS-based data as of 10/15/21. For additional information on the methodology of these precipitation outputs, see Supporting Documents.

While Total Precipitation Depth & Peak Intensity for 24-hour Design Storms are useful to inform planning and design, it is recommended to also consider additional longer- and shorter-duration precipitation events and intensities in accordance with best practices. Longer-duration, lower-intensity storms allow time for infiltration and reduce the load on infrastructure over the duration of the storm. Shorter-duration, higher-intensity storms often have higher runoff volumes because the water does not have enough time to infiltrate infrastructure systems (e.g., catch basins) and may overflow or back up during such storms, resulting in flooding. In the Northeast, short-duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. While the Tool does not provide recommended design standards for these scenarios, users should still consider both short- and long-duration precipitation events and how they may impact the asset.

The projected values, standards, and guidance provided within this Tool may be used to inform plans and designs, but they do not provide guarantees for future conditions or resilience. The projected values are not to be considered final or appropriate for construction documents without supporting engineering analyses. The guidance provided within this Tool is intended to be general and users are encouraged to do their own due diligence

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
FINLAY ROAD PUMP STATION	2070	50-Year (2%)	8.2	Downloadable Methodology PDF

Projected Riverine Peak Discharge & Peak Flood Elevation: NOT APPLICABLE

Extreme Heat — High Risk

Target Planning Horizon: 2070
Percentile: 90th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Annual/Summer/Winter Average Temperatures: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Heat Index: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Growing Degree Days: NOT APPLICABLE

Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Number of Heat Waves Per Year & Average Heat Wave Duration: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Cooling Degree Days & Heating Degree Days (base = 65°F): APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Project Inputs

Core Project Information

Name:	ORLEANS- FINLAY ROAD PUMP STATION
Given the expected useful life of the project, through what year do you estimate the project to last (i.e. before a major reconstruction/renovation)?	2076
Location of Project:	Orleans
Estimated Capital Cost:	$5,000,000
Who is the Submitting Entity?	Private Other AECOM Nick Golben (nick.golben@aecom.com)
Is this project being submitted as part of a state grant application?	No
Which grant program?	
What stage are you in your project lifecycle?	Pre-Planning
Is climate resiliency a core objective of this project?	Yes
Is this project being submitted as part of the state capital planning process?	No
Is this project being submitted as part of a regulatory review process or permitting?	Yes
Brief Project Description:	Identify risk considerations when planning, designing, and constructing wastewater infrastructure that will improve water quality in Orleans.
Project Submission Comments:	

Project Ecosystem Service Benefits

Factors Influencing Output

- ✓ Project improves water quality
- ✓ Project protects fisheries, wildlife, and plant habitat
- ✓ Project protects land containing shellfish
- ✓ Project remediates existing sources of pollution
- ✓ Project prevents pollution

Factors to Improve Output

- ✓ Incorporate nature-based solutions that may provide flood protection
- ✓ Incorporate nature-based solutions that may reduce storm damage
- ✓ Protect public water supply by reducing the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption
- ✓ Incorporate strategies that reduce carbon emissions
- ✓ Incorporate green infrastructure or nature-based solutions that recharge groundwater
- ✓ Incorporate green infrastructure to filter stormwater
- ✓ Incorporate nature-based solutions that sequester carbon carbon
- ✓ Incorporate vegetation that provides pollinator habitat
- ✓ Provide opportunities for passive and/or active recreation through open space
- ✓ Increase plants, trees, and/or other vegetation to provide oxygen production
- ✓ Mitigate atmospheric greenhouse gas concentrations and other toxic air pollutants through nature-based solutions
- ✓ Incorporate education and/or protect cultural resources as part of your project

Is the primary purpose of this project ecological restoration?

No

Project Benefits

Provides flood protection through nature-based solutions	No
Reduces storm damage	No
Recharges groundwater	No
Protects public water supply	No
Filters stormwater using green infrastructure	No
Improves water quality	Yes
Promotes decarbonization	No
Enables carbon sequestration	No
Provides oxygen production	No
Improves air quality	No
Prevents pollution	Yes
Remediates existing sources of pollution	Yes
Protects fisheries, wildlife, and plant habitat	Yes
Protects land containing shellfish	Yes
Provides pollinator habitat	No
Provides recreation	No
Provides cultural resources/education	No

Project Climate Exposure

Is the primary purpose of this project ecological restoration?	No

Does the project site have a history of coastal flooding?	No
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	Unsure
Does the project site have a history of riverine flooding?	No
Does the project result in a net increase in impervious area of the site?	Unsure
Are existing trees being removed as part of the proposed project?	Unsure

Project Assets

Asset: FINLAY ROAD PUMP STATION
Asset Type: Typically Unoccupied
Asset Sub-Type: Pump Station - Sanitary
Construction Type: New Construction
Construction Year: 2026
Useful Life: 50

Identify the length of time the asset can be inaccessible/inoperable without significant consequences.
Building must be accessible/operable at all times, even during natural hazard event

Identify the geographic area directly affected by permanent loss or significant inoperability of the building/facility.
Impacts would be regional (more than one municipality and/or surrounding region)

Identify the population directly served that would be affected by the permanent loss of use or inoperability of the building/facility.
Greater than 10,000 people

Identify if the building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.

If the building/facility became inoperable for longer than acceptable in Question 1, how, if at all, would it be expected to impact people's health and safety?
Inoperability of the building/facility would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses

If there are hazardous materials in your building/facility, what are the extent of impacts related to spills/releases of these materials?
Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety (E.g. wastewater treatment plant; biohazard laboratory)

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts on other facilities, assets, and/or infrastructure?
Significant – Inoperability is likely to impact other facilities, assets, or buildings and will likely affect their ability to operate

If this building/facility was damaged beyond repair, how much would it approximately cost to replace?
Between $10 million and $30 million

Is this a recreational facility which can be vacated during a natural hazard event?
No

If the building/facility became inoperable for longer than acceptable in Question 1, what are the public and/or social services impacts?
No alternative programs and/or services are available to support the community

If the building/facility became inoperable for longer than acceptable in Question 1, what are the environmental impacts related to natural resources?
Impact on natural resources will require remediation/rehabilitation

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to government services (i.e. the building is not able to serve or operate its intended users or function)?
Loss of building may reduce the ability to maintain some government services, while a majority of services will still exist.

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to loss of confidence in government (i.e. the building is not able to serve or operate its intended users or function)?
Loss of confidence in government agency

Report Comments

N/A

Climate Resilience Design Standards Tool Project Report

ORLEANS- AUNT ABIGAILS WAY PUMP STATION

Date Created: 11/16/2023 1:48:55 PM
Created By: Nickgolben1
Date Report Generated: 11/20/2023 4:55:14 PM
Tool Version: Version 1.2
Project Contact Information: Nick Golben (nick.golben@aecom.com)

Project Summary

Link to Project

Estimated Capital Cost: $5000000.00
End of Useful Life Year: 2091
Project within mapped Environmental Justice neighborhood: No

Ecosystem Service Benefits	Scores
Project Score	Low
Exposure	**Scores**
Sea Level Rise/Storm Surge	Not Exposed
Extreme Precipitation - Urban Flooding	Moderate Exposure
Extreme Precipitation - Riverine Flooding	High Exposure
Extreme Heat	Moderate Exposure



Asset Preliminary Climate Risk Rating Summary

Number of Assets: 1

Asset Risk	Sea Level Rise/Storm Surge	Extreme Precipitation - Urban Flooding	Extreme Precipitation - Riverine Flooding	Extreme Heat
AUNT ABIGAILS WAY PUMP STATION	Low Risk	High Risk	High Risk	High Risk

Climate Resilience Design Standards Summary

	Target Planning Horizon	Intermediate Planning Horizon	Percentile	Return Period	Tier
Sea Level Rise/Storm Surge					
AUNT ABIGAILS WAY PUMP STATION					
Extreme Precipitation					
AUNT ABIGAILS WAY PUMP STATION	2070			50-yr (2%)	Tier 3
Extreme Heat					
AUNT ABIGAILS WAY PUMP STATION	2070		90th		Tier 3

Scoring Rationale - Project Exposure Score

The purpose of the Exposure Score output is to provide a preliminary assessment of whether the overall project site and subsequent assets are exposed to impacts of natural hazard events and/or future impacts of climate change. For each climate parameter, the Tool will calculate one of the following exposure ratings: Not Exposed, Low Exposure, Moderate Exposure, or High Exposure. The rationale behind the exposure rating is provided below.

Sea Level Rise/Storm Surge

This project received a "Not Exposed" because of the following:

- Not located within the predicted mean high water shoreline by 2030
- No historic coastal flooding at project site
- Not located within the Massachusetts Coast Flood Risk Model (MC-FRM)

Extreme Precipitation - Urban Flooding

This project received a "Moderate Exposure" because of the following:

- Maximum annual daily rainfall exceeds 10 inches within the overall project's useful life
- No historic flooding at project site
- No increase to impervious area
- Existing impervious area of the project site is less than 10%

Extreme Precipitation - Riverine Flooding

This project received a "High Exposure" because of the following:

- Part of the project is within a mapped FEMA floodplain, outside of the Massachusetts Coast Flood Risk Model (MC-FRM)
- Part of the project is within 100ft of a waterbody
- No historic riverine flooding at project site
- Project is not likely susceptible to riverine erosion

Extreme Heat

This project received a "Moderate Exposure" because of the following:

- Existing impervious area of the project site is less than 10%
- 10 to 30 day increase in days over 90 deg. F within project's useful life
- Located within 100 ft of existing water body
- No increase to the impervious area of the project site
- No tree removal

Scoring Rationale - Asset Preliminary Climate Risk Rating

A Preliminary Climate Risk Rating is determined for each infrastructure and building asset by considering the overall project Exposure Score and responses to Step 4 questions provided by the user in the Tool. Natural Resource assets do not receive a risk rating. The following factors are what influenced the risk ratings for each asset.

Asset - AUNT ABIGAILS WAY PUMP STATION
Primary asset criticality factors influencing risk ratings for this asset:

- Asset must be operable at all times, even during natural hazard event
- Greater than 10,000 people would be directly affected by the loss/inoperability of the asset
- The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
- Inoperability of the asset would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses
- Inoperability is likely to significantly impact other facilities, assets, or buildings and will likely affect their ability to operate
- Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety

Project Climate Resilience Design Standards Output

Climate Resilience Design Standards and Guidance are recommended for each asset and climate parameter. The Design Standards for each climate parameter include the following: recommended planning horizon (target and/or intermediate), recommended return period (Sea Level Rise/Storm Surge and Precipitation) or percentile (Heat), and a list of applicable design criteria that are likely to be affected by climate change. Some design criteria have numerical values associated with the recommended return period and planning horizon, while others have tiered methodologies with step-by-step instructions on how to estimate design values given the other recommended design standards.

Asset: AUNT ABIGAILS WAY PUMP STATION — Building/Facility

Sea Level Rise/Storm Surge — Low Risk

Applicable Design Criteria

Projected Tidal Datums: NOT APPLICABLE

Projected Water Surface Elevation: NOT APPLICABLE

Projected Wave Action Water Elevation: NOT APPLICABLE

Projected Wave Heights: NOT APPLICABLE

Projected Duration of Flooding: NOT APPLICABLE

Projected Design Flood Velocity: NOT APPLICABLE

Projected Scour & Erosion: NOT APPLICABLE

Extreme Precipitation — High Risk

Target Planning Horizon: 2070
Return Period: 50-yr (2%)

LIMITATIONS: The recommended Standards for Total Precipitation Depth & Peak Intensity are determined by the user drawn polygon and relationships as defined in the Supporting Documents. The projected Total Precipitation Depth values provided through the Tool are based on the climate projections developed by Cornell University as part of EEA's Massachusetts Climate and Hydrologic Risk Project, GIS-based data as of 10/15/21. For additional information on the methodology of these precipitation outputs, see Supporting Documents.

While Total Precipitation Depth & Peak Intensity for 24-hour Design Storms are useful to inform planning and design, it is recommended to also consider additional longer- and shorter-duration precipitation events and intensities in accordance with best practices. Longer-duration, lower-intensity storms allow time for infiltration and reduce the load on infrastructure over the duration of the storm. Shorter-duration, higher-intensity storms often have higher runoff volumes because the water does not have enough time to infiltrate infrastructure systems (e.g., catch basins) and may overflow or back up during such storms, resulting in flooding. In the Northeast, short-duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. While the Tool does not provide recommended design standards for these scenarios, users should still consider both short- and long-duration precipitation events and how they may impact the asset.

The projected values, standards, and guidance provided within this Tool may be used to inform plans and designs, but they do not provide guarantees for future conditions or resilience. The projected values are not to be considered final or appropriate for construction documents without supporting engineering analyses. The guidance provided within this Tool is intended to be general and users are encouraged to do their own due diligence

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: APPLICABLE

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
AUNT ABIGAILS WAY PUMP STATION	2070	50-Year (2%)	8.2	Downloadable Methodology PDF

Projected Riverine Peak Discharge & Peak Flood Elevation: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Extreme Heat High Risk

Target Planning Horizon: 2070
Percentile: 90th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 3

Projected Annual/Summer/Winter Average Temperatures: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Heat Index: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Growing Degree Days: NOT APPLICABLE

Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Number of Heat Waves Per Year & Average Heat Wave Duration: APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Projected Cooling Degree Days & Heating Degree Days (base = 65°F): APPLICABLE
Methodology to Estimate Projected Values : Tier 3

Project Inputs

Core Project Information

Name:	ORLEANS- AUNT ABIGAILS WAY PUMP STATION
Given the expected useful life of the project, through what year do you estimate the project to last (i.e. before a major reconstruction/renovation)?	2091
Location of Project:	Orleans
Estimated Capital Cost:	$5,000,000
Who is the Submitting Entity?	Private Other AECOM Nick Golben (nick.golben@aecom.com)
Is this project being submitted as part of a state grant application?	No
Which grant program?	
What stage are you in your project lifecycle?	Pre-Planning
Is climate resiliency a core objective of this project?	Yes
Is this project being submitted as part of the state capital planning process?	No
Is this project being submitted as part of a regulatory review process or permitting?	Yes
Brief Project Description:	Identify risk considerations when planning, designing, and constructing wastewater infrastructure that will improve water quality in Orleans.
Project Submission Comments:	

Project Ecosystem Service Benefits

Factors Influencing Output

- ✓ Project improves water quality
- ✓ Project protects fisheries, wildlife, and plant habitat
- ✓ Project protects land containing shellfish
- ✓ Project remediates existing sources of pollution
- ✓ Project prevents pollution

Factors to Improve Output

- ✓ Incorporate nature-based solutions that may provide flood protection
- ✓ Incorporate nature-based solutions that may reduce storm damage
- ✓ Protect public water supply by reducing the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption
- ✓ Incorporate strategies that reduce carbon emissions
- ✓ Incorporate green infrastructure or nature-based solutions that recharge groundwater
- ✓ Incorporate green infrastructure to filter stormwater
- ✓ Incorporate nature-based solutions that sequester carbon carbon
- ✓ Incorporate vegetation that provides pollinator habitat
- ✓ Provide opportunities for passive and/or active recreation through open space
- ✓ Increase plants, trees, and/or other vegetation to provide oxygen production
- ✓ Mitigate atmospheric greenhouse gas concentrations and other toxic air pollutants through nature-based solutions
- ✓ Incorporate education and/or protect cultural resources as part of your project

Is the primary purpose of this project ecological restoration?

No

Project Benefits

Provides flood protection through nature-based solutions	No
Reduces storm damage	No
Recharges groundwater	No
Protects public water supply	No
Filters stormwater using green infrastructure	No
Improves water quality	Yes
Promotes decarbonization	No
Enables carbon sequestration	No
Provides oxygen production	No
Improves air quality	No
Prevents pollution	Yes
Remediates existing sources of pollution	Yes
Protects fisheries, wildlife, and plant habitat	Yes
Protects land containing shellfish	Yes
Provides pollinator habitat	No
Provides recreation	No
Provides cultural resources/education	No

Project Climate Exposure

Is the primary purpose of this project ecological restoration?	No

Does the project site have a history of coastal flooding?	No
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	Unsure
Does the project site have a history of riverine flooding?	No
Does the project result in a net increase in impervious area of the site?	Unsure
Are existing trees being removed as part of the proposed project?	Unsure

Project Assets

Asset: AUNT ABIGAILS WAY PUMP STATION
Asset Type: Typically Unoccupied
Asset Sub-Type: Pump Station - Sanitary
Construction Type: New Construction
Construction Year: 2041
Useful Life: 50

Identify the length of time the asset can be inaccessible/inoperable without significant consequences.
Building must be accessible/operable at all times, even during natural hazard event

Identify the geographic area directly affected by permanent loss or significant inoperability of the building/facility.
Impacts would be regional (more than one municipality and/or surrounding region)

Identify the population directly served that would be affected by the permanent loss of use or inoperability of the building/facility.
Greater than 10,000 people

Identify if the building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
The building/facility provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.

If the building/facility became inoperable for longer than acceptable in Question 1, how, if at all, would it be expected to impact people's health and safety?
Inoperability of the building/facility would result in moderate or severe injuries or moderate or severe impacts to chronic illnesses

If there are hazardous materials in your building/facility, what are the extent of impacts related to spills/releases of these materials?
Spills and/or releases of hazardous materials are expected with difficult remediation and pose a severe threat to public health or safety (E.g. wastewater treatment plant; biohazard laboratory)

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts on other facilities, assets, and/or infrastructure?
Significant – Inoperability is likely to impact other facilities, assets, or buildings and will likely affect their ability to operate

If this building/facility was damaged beyond repair, how much would it approximately cost to replace?
Between $10 million and $30 million

Is this a recreational facility which can be vacated during a natural hazard event?
No

If the building/facility became inoperable for longer than acceptable in Question 1, what are the public and/or social services impacts?
No alternative programs and/or services are available to support the community

If the building/facility became inoperable for longer than acceptable in Question 1, what are the environmental impacts related to natural resources?
Impact on natural resources will require remediation/rehabilitation

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to government services (i.e. the building is not able to serve or operate its intended users or function)?
Loss of building may reduce the ability to maintain some government services, while a majority of services will still exist.

If the building/facility became inoperable for longer than acceptable in Question 1, what are the impacts to loss of confidence in government (i.e. the building is not able to serve or operate its intended users or function)?
Loss of confidence in government agency

Report Comments

N/A

ATTACHMENT V

ENVIRONMENTAL JUSTICE ADVANCE NOTIFICATION

Environmental Justice Screening Form

Project Name	Town of Orleans Amended Comprehensive Wastewater Management Plan (ACWMP)
Anticipated Date of MEPA Filing	December 30, 2023
Proponent Name	Town of Orleans
Contact Information (e.g., consultant)	AECOM, Jennifer Doyle-Breen Email: jennifer.doyle-breen@aecom.com
Public website for project or other physical location where project materials can be obtained (if available)	www.town.orleans.ma.us
Municipality and Zip Code for Project (if known)	Orleans, MA 02643
Project Type* (list all that apply)	Wastewater – CWMP Aquaculture/shellfish Wastewater – Treatment/conveyance
Is the project site within a mapped 100-year FEMA flood plain? Y/N/ unknown	Yes
Estimated GHG emissions of conditioned spaces (click **here** for GHG Estimation tool)	Not Applicable

Project Description

1. Provide a brief project description, including overall size of the project site and square footage of proposed buildings and structures if known.

This project is an update to the previously reviewed 2010 Comprehensive Wastewater Management Plan/Single Environmental Impact Report (CWMP/SEIR) and two subsequent Notices of Project Change for the Town of Orleans, based on additional studies and wastewater engineering and planning decisions that have occurred since approval of the CWMP in 2011. The Amended Comprehensive Wastewater Management Plan (ACWMP) builds upon earlier studies and data collection completed for the 2010 CWMP/SEIR and provides an update on the additional planning and engineering efforts that were completed since CWMP approval in 2011 and two subsequent NPCs. The ACWMP has been developed to provide an update on the Town's plans to meet their nitrogen removal goals The ACWMP is being submitted to MEPA for review as a third NPC, as requested by MEPA in the 2019 NPC MEPA Certificate.

The material changes to the previously reviewed project include the following:

- Revisions to the sewer phase boundaries while substantially maintaining the originally sewered area limits
- Extension of the time period to construct wastewater collection facilities in these sewer phases

- Identification of Permeable Reactive Barrier sites for further evaluation and full-scale implementation

- Elimination of consideration of aquaculture at sites other than Lonnie's Pond

- Elimination of consideration of other NT Technologies for nitrogen removal

The Town of Orleans has revised the sewer phasing and the anticipated construction time frame for each phase. The 2023 phases correspond to the 2010 CWMP "Core Area" but extend the time period for completing sewer installation in these areas through 2067 due to multiple considerations, including the Town's need to address other financial needs and continuing studies on Permeable Reactive Barriers (PRBs) and nitrogen attenuation.

AECOM performed a preliminary assessment for nitrogen removal effectiveness of PRBs and has identified four locations for further investigation regarding full-scale implementation.

The 2019 NPC described full-scale implementation of an aquaculture project at Lonnie's Pond, which has been underway for five years. The Town plans to continue aquaculture at Lonnie's Pond as a Non-Traditional approach to nitrogen removal. Other aquaculture sites were evaluated but determined to be not cost-effective. The Town does not plan to implement aquaculture at any other sites at this time and does not plan to implement any NT technologies other than PRBs and aquaculture.

The overall size of the project site and square footage of proposed buildings and structures are summarized below:

- The total area of all sewer phases is approximately 27.4 acres; sewers will be installed below grade.
- The approximate square footage of the wastewater treatment facility (WWTF) is 59,200 square feet.
- There are 12 proposed pump stations, each of which is approximately 1,000 square feet.

2. List anticipated MEPA review thresholds (301 CMR 11.03) (if known)

The review thresholds listed below were previously triggered by the original project and remain for the revised project. No new thresholds are triggered by the project change.

301 CMR 11.03(11)(b) Areas of Critical Environmental Concern (ACEC). Project within a designated ACEC.

301 CMR 11.03(5)(a)(3) Wastewater. Construction of one or more new sewer mains ten or more miles in length.

301 CMR 11.03(5)(b)(1) Wastewater. Construction of a new wastewater treatment and/or disposal facility with a capacity of 100,000 gpd or more.

301 CMR 11.03(5)(b)(4)(c)(ii) Wastewater. New discharge to groundwater of 50,000 or more gpd of sewage withing any other area.

3. List all anticipated state, local and federal permits needed for the project (if known)

MassDEP Wetland Protection Act Local Order of Conditions
NHESP Project Review
MassDOT Permit/Approval
US EPA NDPES Construction General Permit for Stormwater Discharges
DMF Certification of Aquaculture
USACE Section 404 General Permits
MassDEP Effluent Discharge Permit
MassDEP Hydrological Approval

4. Identify EJ populations and characteristics (Minority, Income, English Isolation) within 5 miles of project site (can attach map identifying 5-mile radius from EJ Maps Viewer in lieu of narrative)

See Figure 1, Environmental Justice Populations.

5. Identify any municipality or census tract meeting the definition of "vulnerable health EJ criteria" in the DPH EJ Tool located in whole or in part within a 1 mile radius of the project site

Effectively, the project site encompasses the Town of Orleans. There are four additional municipalities within one mile of the project area: Eastham, Brewster, Harwich, and Chatham.

In the most recent year range, tracts within one mile of the project site that meet the vulnerable health EJ criteria comprise census tract 109 in Brewster for low birth rate and census tract 105 in Orleans for low birth rate. No census tracts within the one-mile radius meet the vulnerable health EJ criteria for lead poisoning.

The Towns of Orleans and Harwich meet the vulnerable health EJ criteria for lead poisoning. Brewster, Chatham, and Eastham do not meet any vulnerable health EJ criteria in the most recent year range. The heart attack and childhood asthma criteria are not reported for the census tracts.

The municipality of Brewster does not meet the EJ vulnerable health criteria for low-birth rate, but census tract 109 in Brewster does, this is based on data downloaded from the link provided for the DPH EJ Tool for the most recent year range. Census tracts and municipalities are treated as two separate cases within the one-mile radius of the project site.

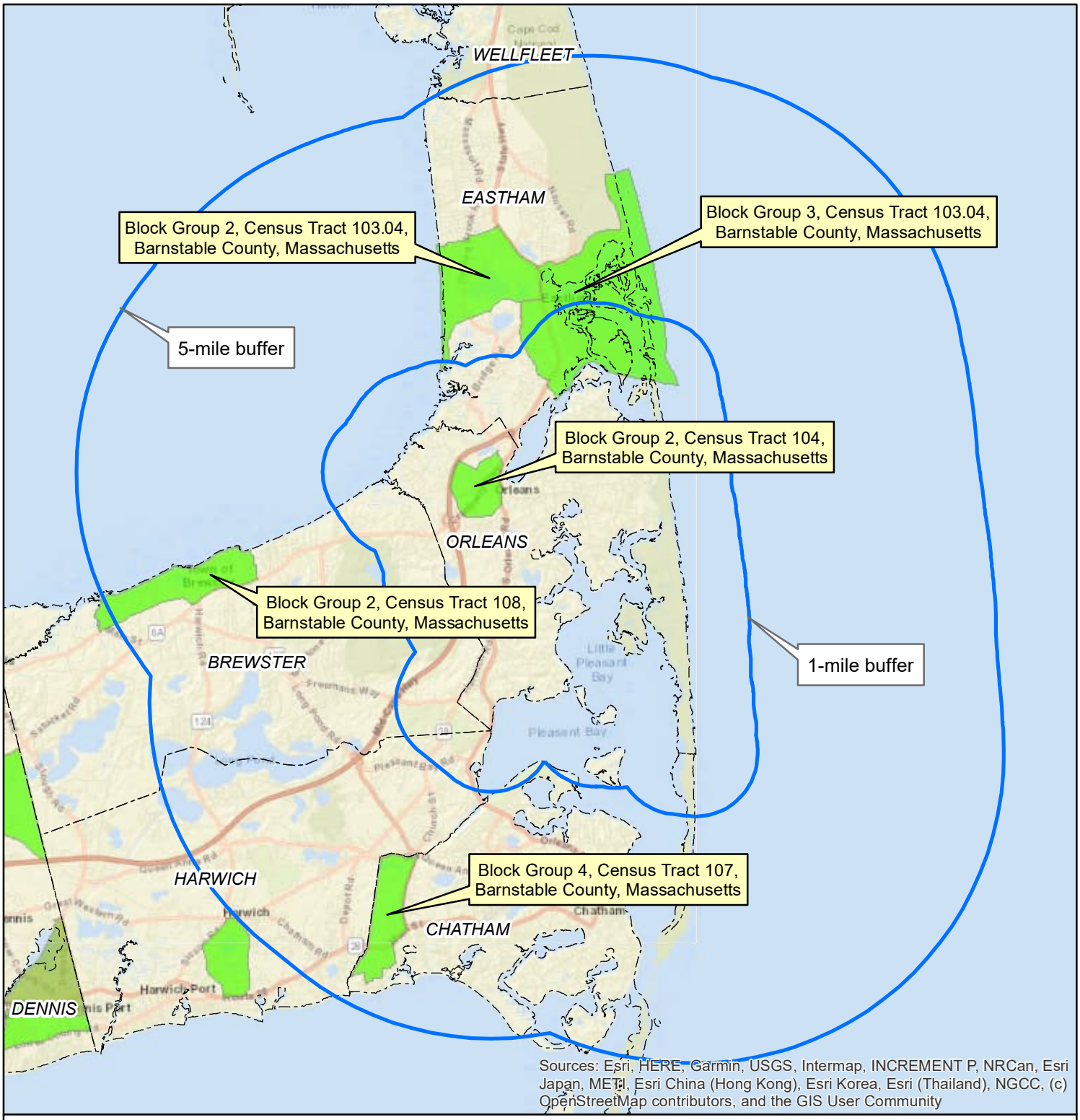
6. Identify potential short-term and long-term environmental and public health impacts that may affect EJ Populations and any anticipated mitigation.

- Short term impact for access to some public streets for the installation of new sewer lines and construction of a new WWTF. This may temporarily disrupt traffic.
- Short term impacts to air quality associated with heavy machinery from construction. Contractors are required to follow the MassDEP Diesel Retrofit Program.
- There may be short term impacts caused by odor. The contractors will restrict odor-generating activities to times of day with the least impact and will implement odor control systems.
- Short term impacts due to noise from construction. Work hours will be restricted at sites near residential areas and noise control systems will be put in place.

These impacts would not result in disproportionate adverse effects on an EJ population.

7. Identify project benefits, including "Environmental Benefits" as defined in 301 CMR 11.02, that may improve environmental conditions or public health of the EJ population. This project will continue to work toward improving the Town's water quality through the implementation of sewering, non-traditional technologies, and adaptive management which will reduce nutrient loading into receiving waters. All of Orleans' residents, including the EJ population, will benefit from having estuaries and ponds with improved water quality, which will support enhanced recreational use, aesthetics, and habitat diversity.
8. Describe how the community can request a meeting to discuss the project, and how the community can request oral language interpretation services at the meeting. Specify how to request other accommodations, including meetings after business hours and at locations near public transportation. To request accommodations please email or call the following: AECOM, Jennifer Doyle-Breen Email: jennifer.doyle-breen@aecom.com Phone: 978-905-2100

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Legend

- Town Boundaries
- Buffers

2020 Environmental Justice Populations Nov 2022 Update

- Income
- Minority and Income

FIGURE 1

ENVIRONMENTAL JUSTICE POPULATIONS

Source: MassEOEEA 2020 Environmental Justice Populations November 2022 Update

N

0 1 2 Miles

AECOM

Date: 11/16/2023

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