Appendix R

Technical Memo –Preliminary Engineering Work Plan for Permeable Reactive Barriers

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Memorandum

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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
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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.

Cape Cod Commission - Cape Cod Area Wide Water Quality Management Plan Update, June 2015.

Interstate Technology & Regulatory Council (ITRC) - Permeable Reactive Barrier: Technology Update (PRB-5), November 2011

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:

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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**	

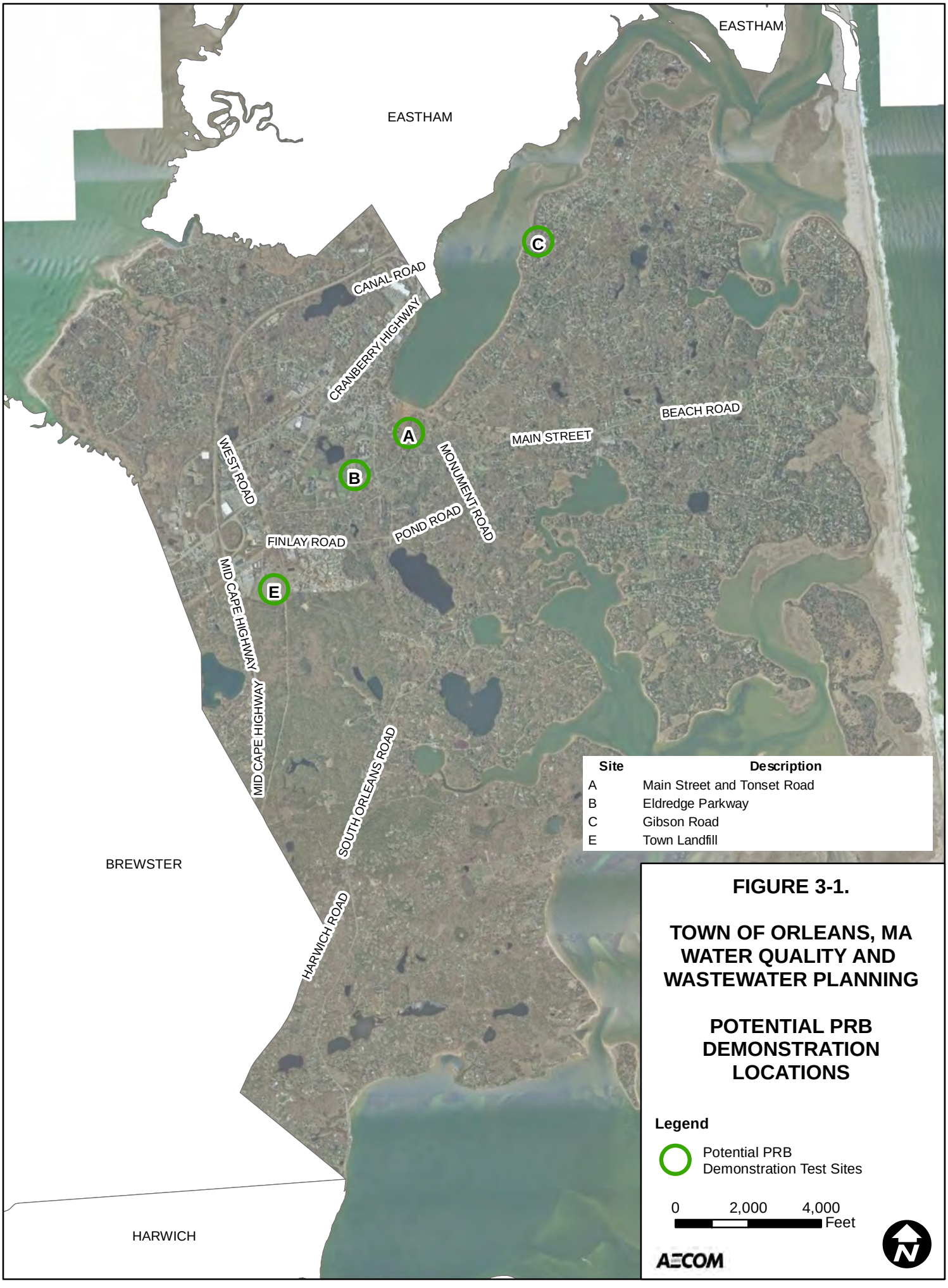
Notes:
bgs = Below Ground Surface
TBD - to be determined

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



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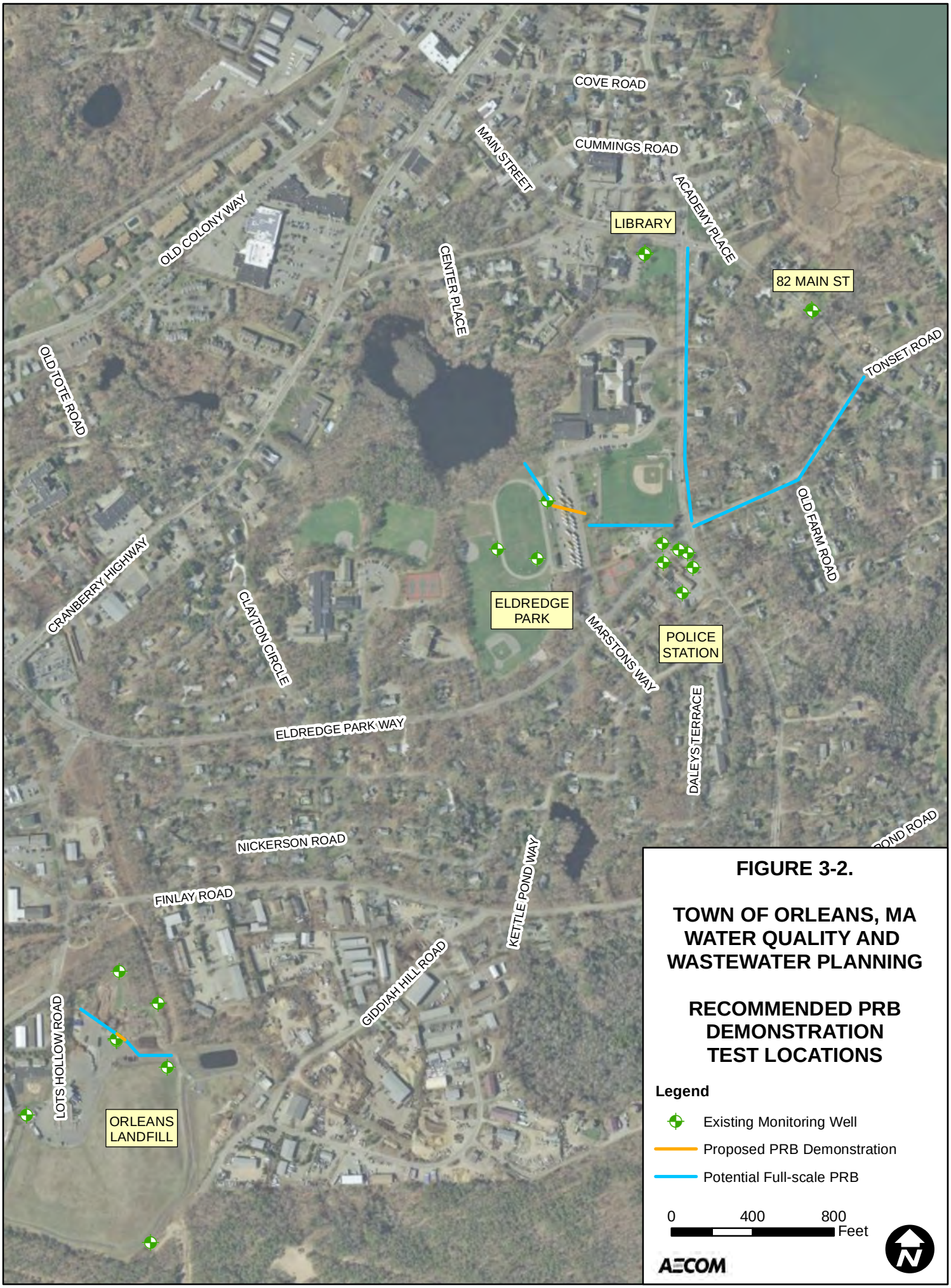

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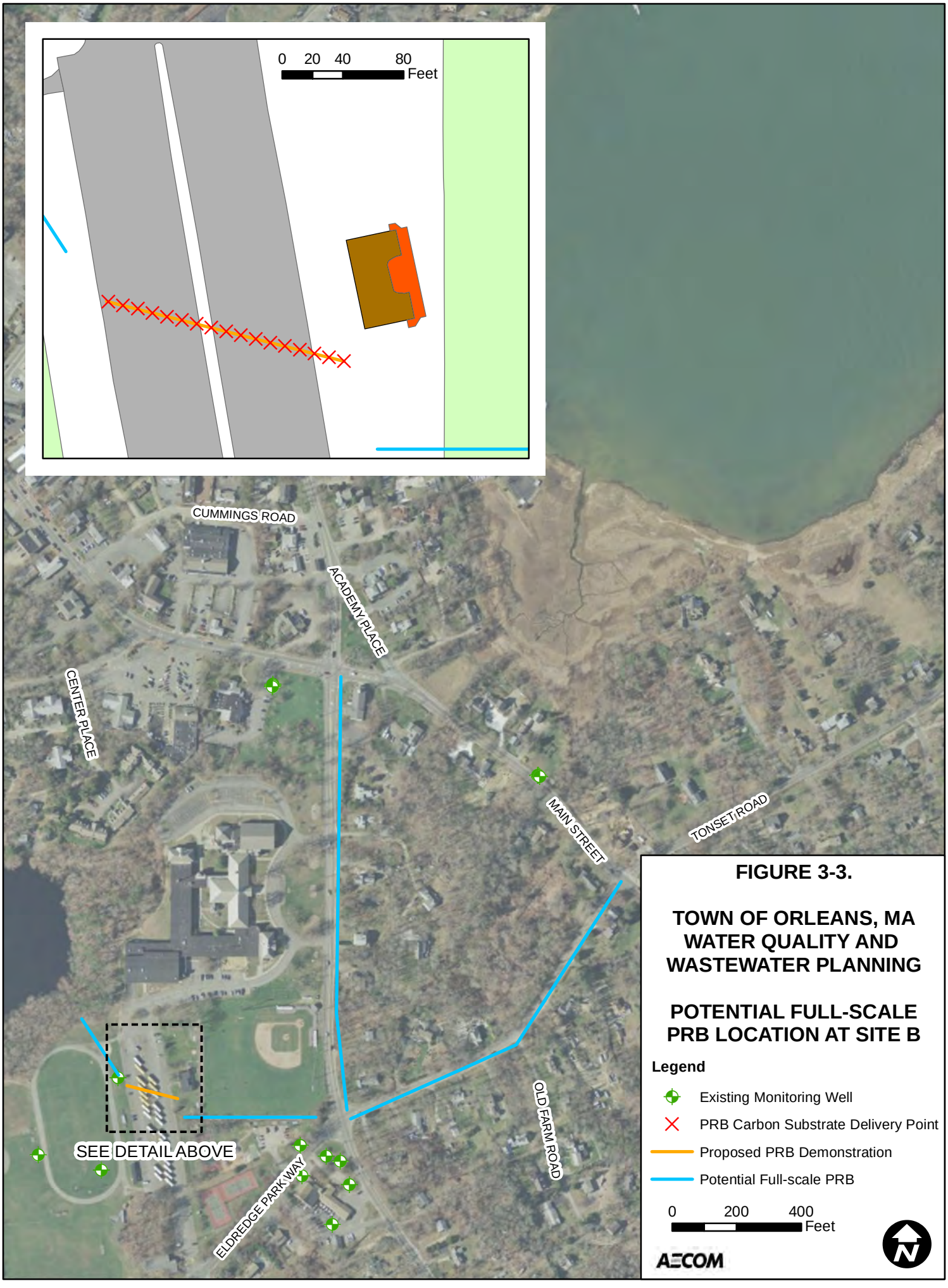

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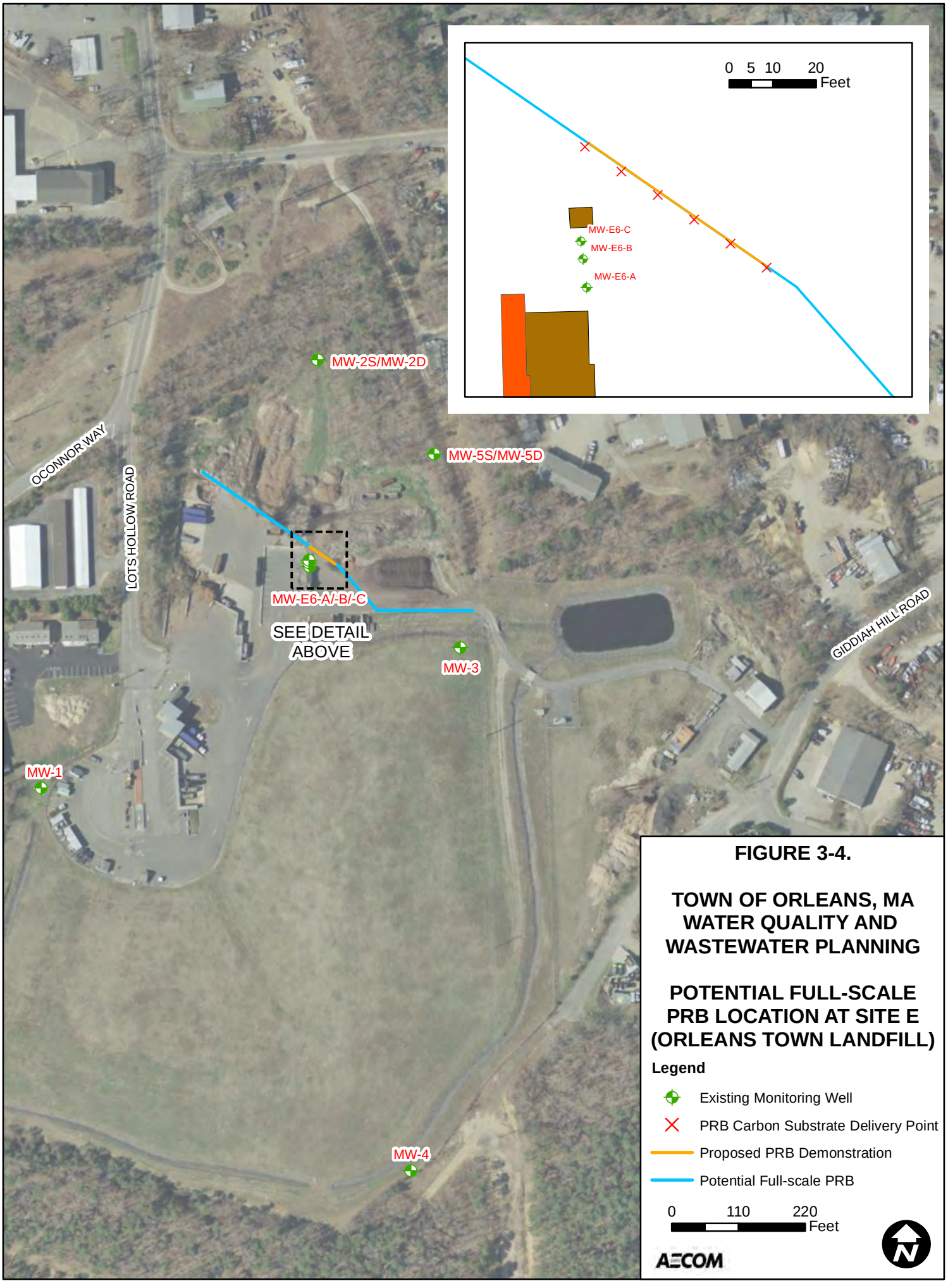

FIGURE 3-4.

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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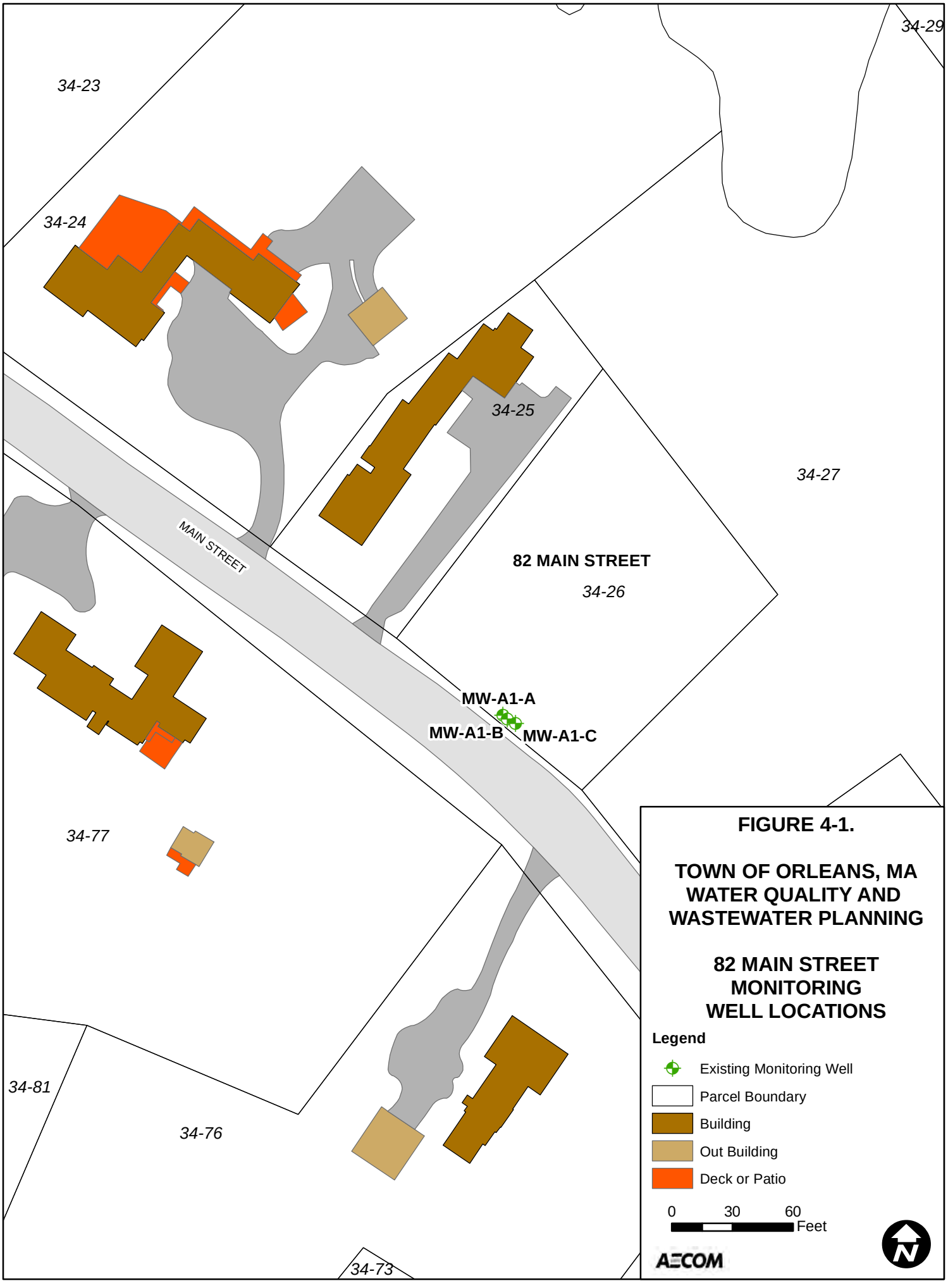
34-29
34-23
34-24
34-25
34-27
MAIN STREET
82 MAIN STREET
34-26
MW-A1-A
MW-A1-B
MW-A1-C
34-77
34-81
34-76
34-73
FIGURE 4-1.
TOWN OF ORLEANS, MA
WATER QUALITY AND
WASTEWATER PLANNING
82 MAIN STREET
MONITORING
WELL LOCATIONS
Legend
Existing Monitoring Well
Parcel Boundary
Building
Out Building
Deck or Patio
0
30
60
Feet
AECOM
N
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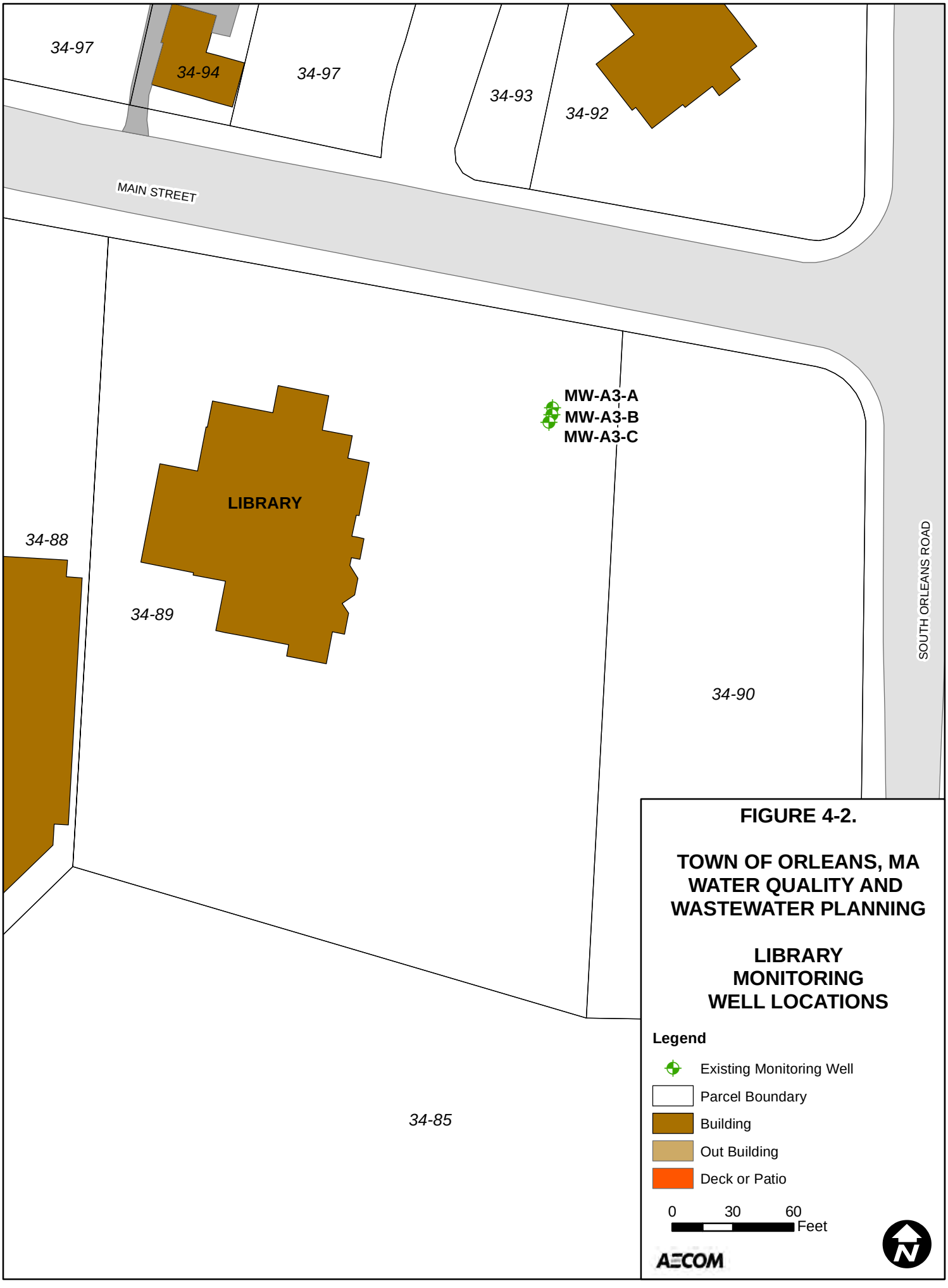
34-97
34-94
34-97
34-93
34-92
MAIN STREET
MW-A3-A
MW-A3-B
MW-A3-C
LIBRARY
34-88
34-89
34-90
SOUTH ORLEANS ROAD
34-85
FIGURE 4-2.
TOWN OF ORLEANS, MA
WATER QUALITY AND
WASTEWATER PLANNING
LIBRARY
MONITORING
WELL LOCATIONS
Legend
Existing Monitoring Well
Parcel Boundary
Building
Out Building
Deck or Patio
0
30
60
Feet
AECOM
N
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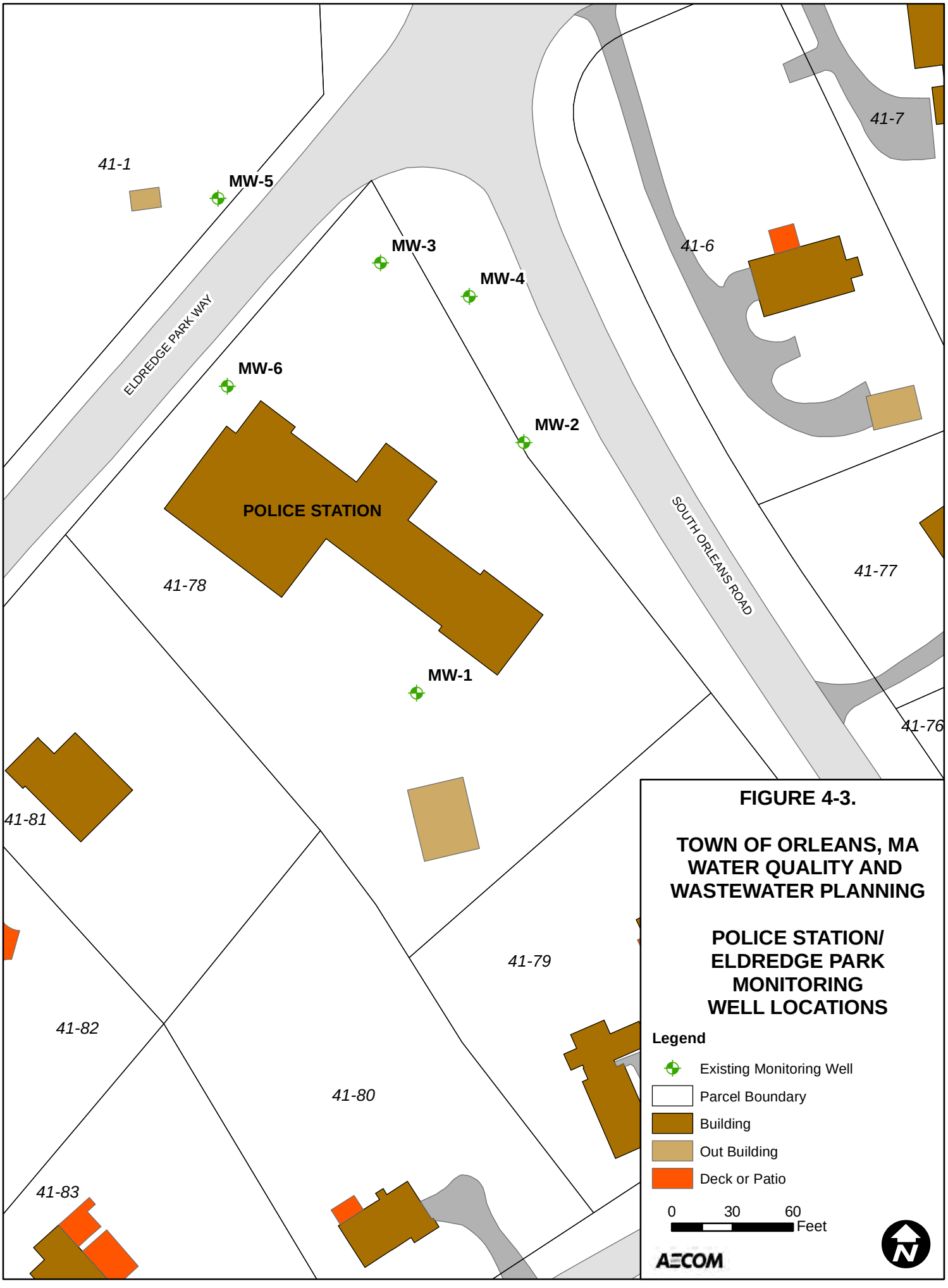
41-1
MW-5
MW-3
MW-4
41-6
41-7
ELDREDGE PARK WAY
MW-6
MW-2
POLICE STATION
SOUTH ORLEANS ROAD
41-78
41-77
MW-1
41-76
41-81
41-79
41-82
41-80
41-83
FIGURE 4-3.
TOWN OF ORLEANS, MA
WATER QUALITY AND
WASTEWATER PLANNING
POLICE STATION/
ELDREDGE PARK
MONITORING
WELL LOCATIONS
Legend
Existing Monitoring Well
Parcel Boundary
Building
Out Building
Deck or Patio
0
30
60
Feet
AECOM
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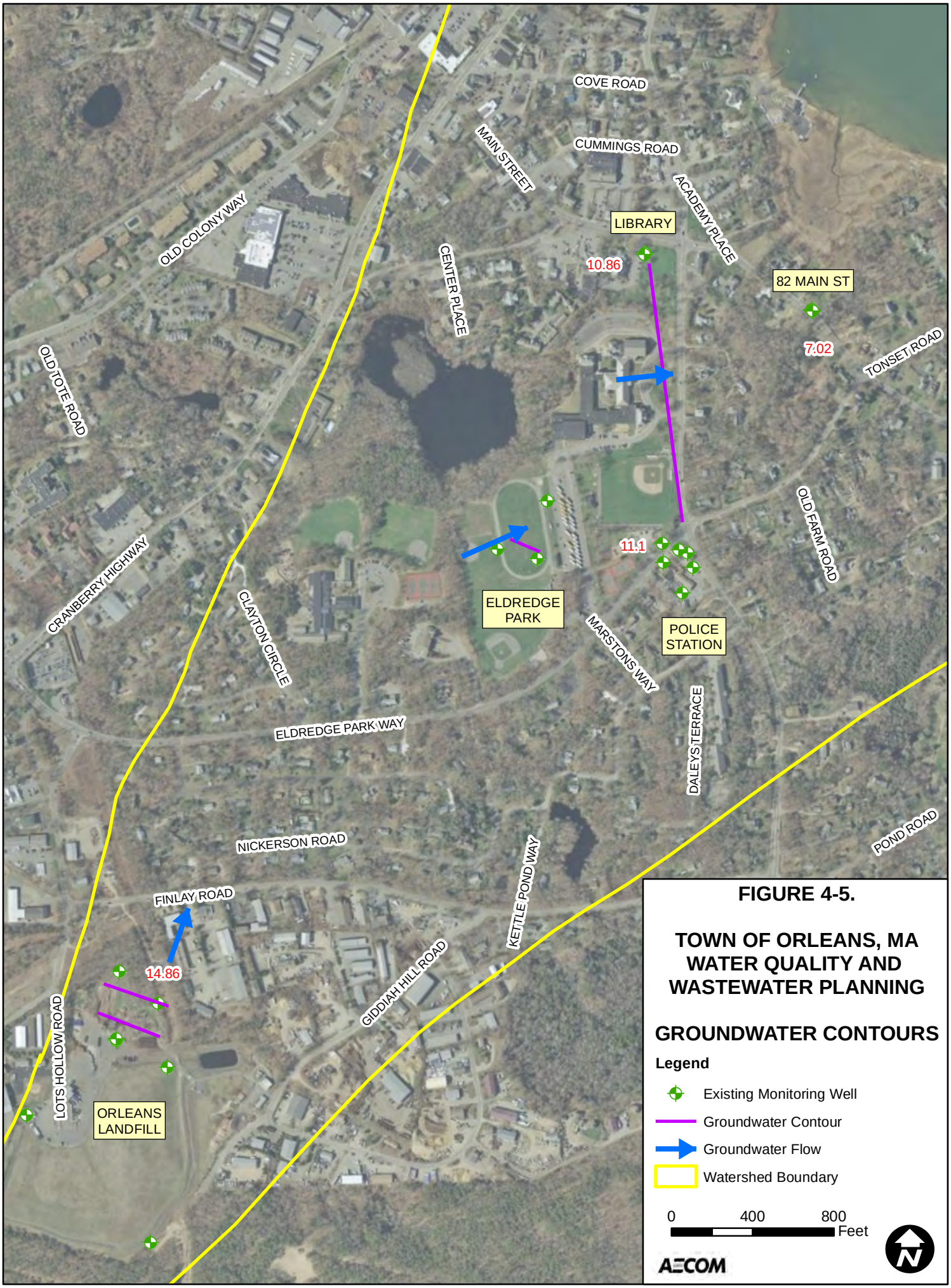

FIGURE 4-5.

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

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MW-B1150
MW-B2175
MW-B1100
MW-B2100
MW-B3100
MW-B1050
MW-B2050
MW-12
MW-BC1
MW-B3050
MW-B1020
MW-B1010
MW-B2020
MW-B2010
MW-B3020
MW-B3010
MW-BU1
MW-BC2
MW-BU2
MW-4
MW-8

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

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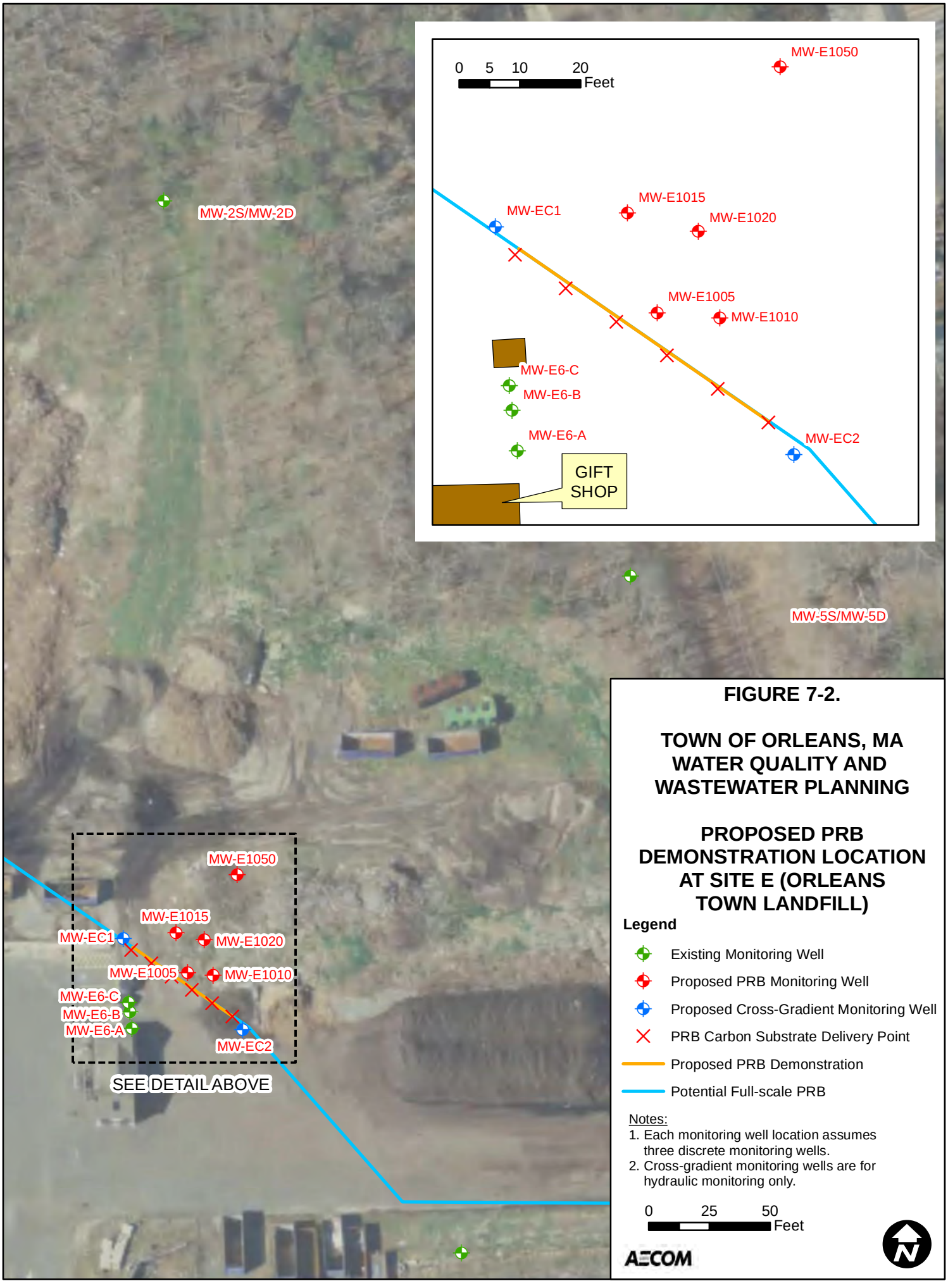

FIGURE 7-2.

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

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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

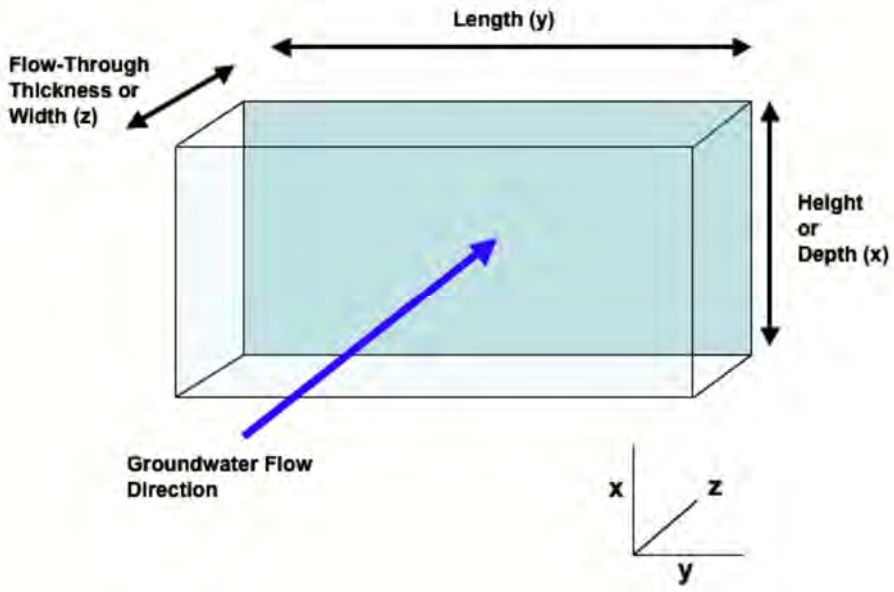
- excavating a long deep trench to place reactive solid material in the path of target groundwater,
- using soil boring and/or wells to inject a reactive liquid or emulsion in the path or target groundwater flow, and
- using soil borings and wells to place a solid reactive material in the path of target 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

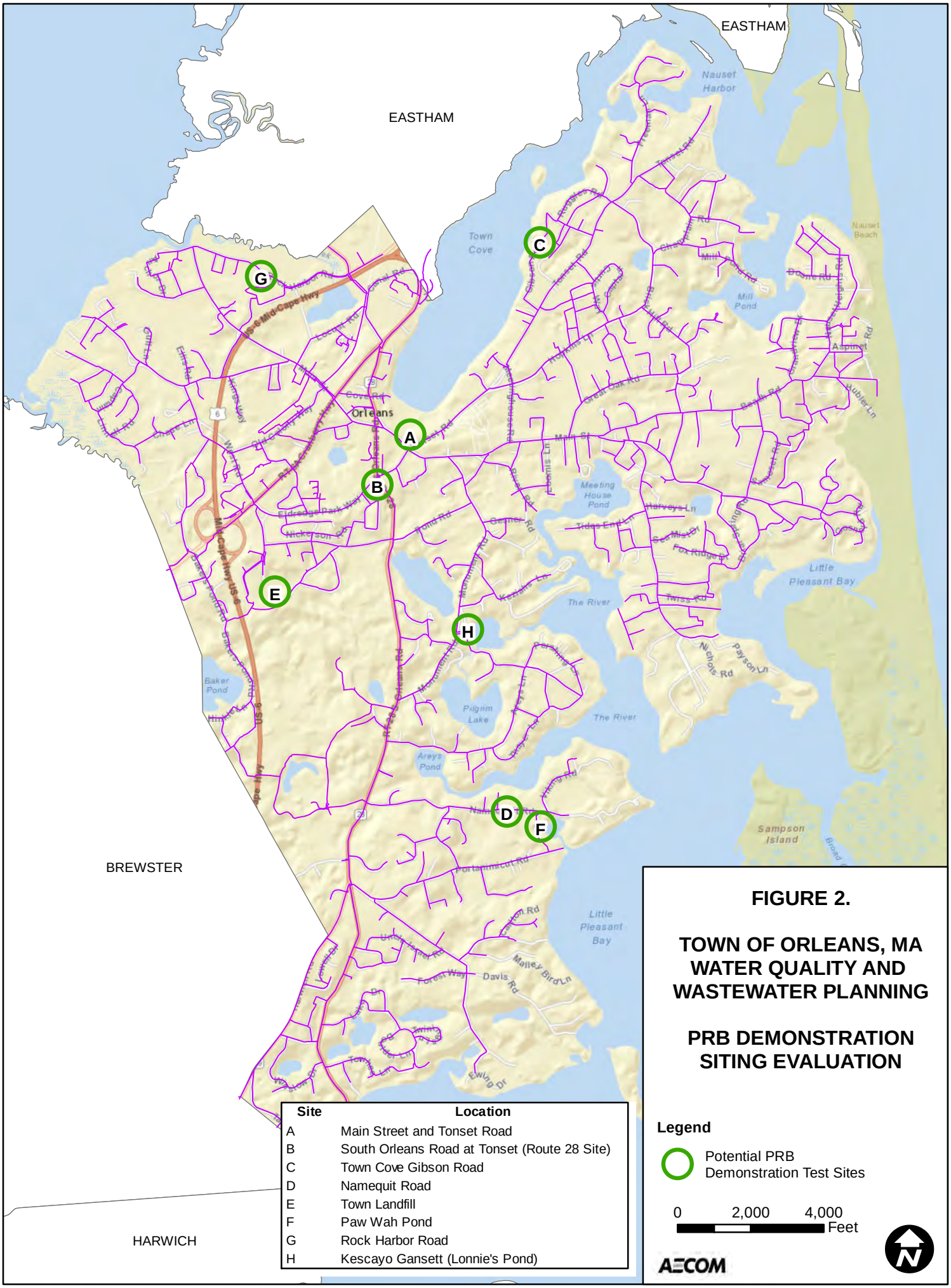
ORLEANS HYBRID VERSION 3
WQAP MEETING 2-11-15

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

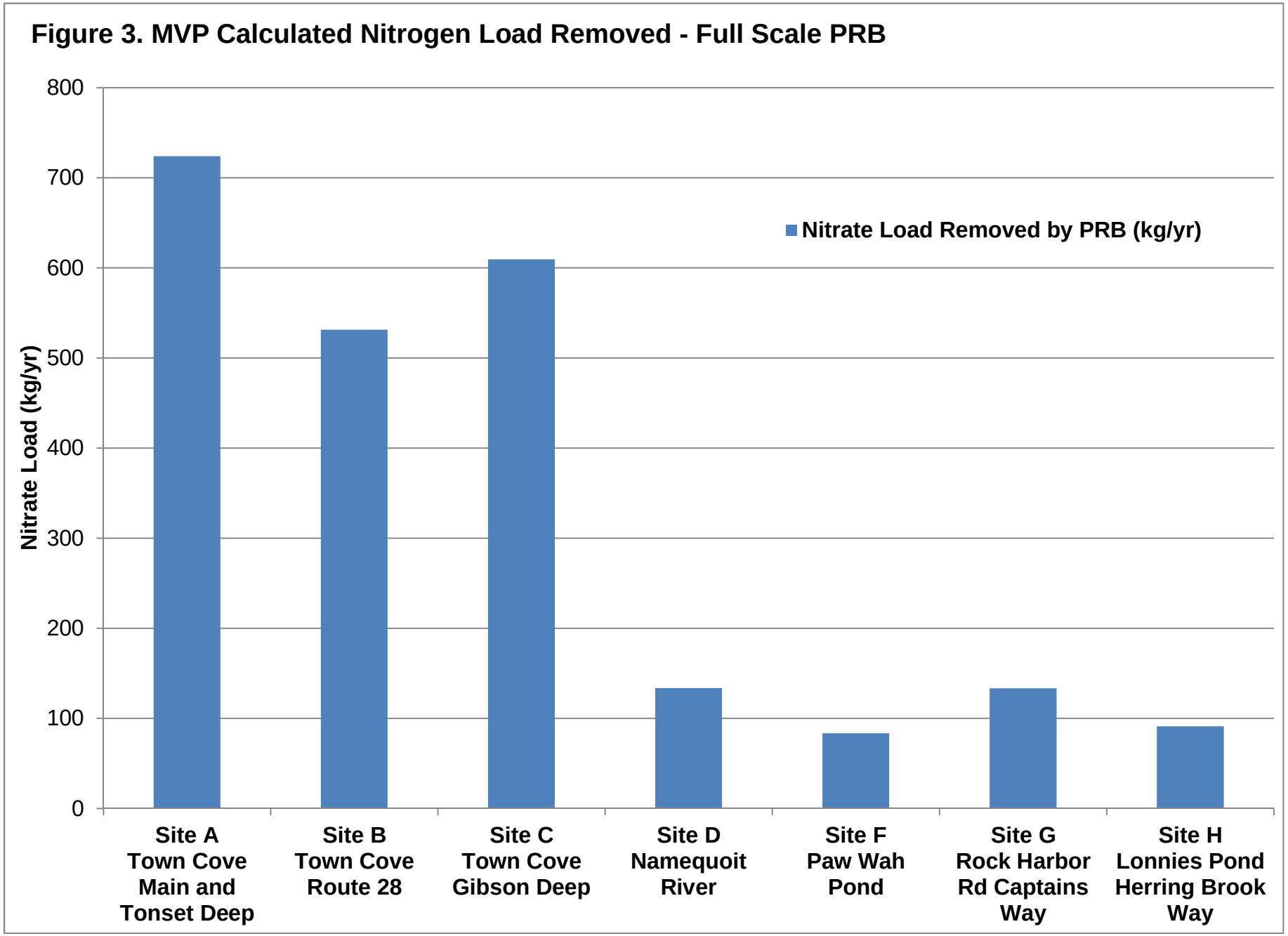


Figure 4. MVP Calculated Nitrate Load Removed Per PRB Length Unit

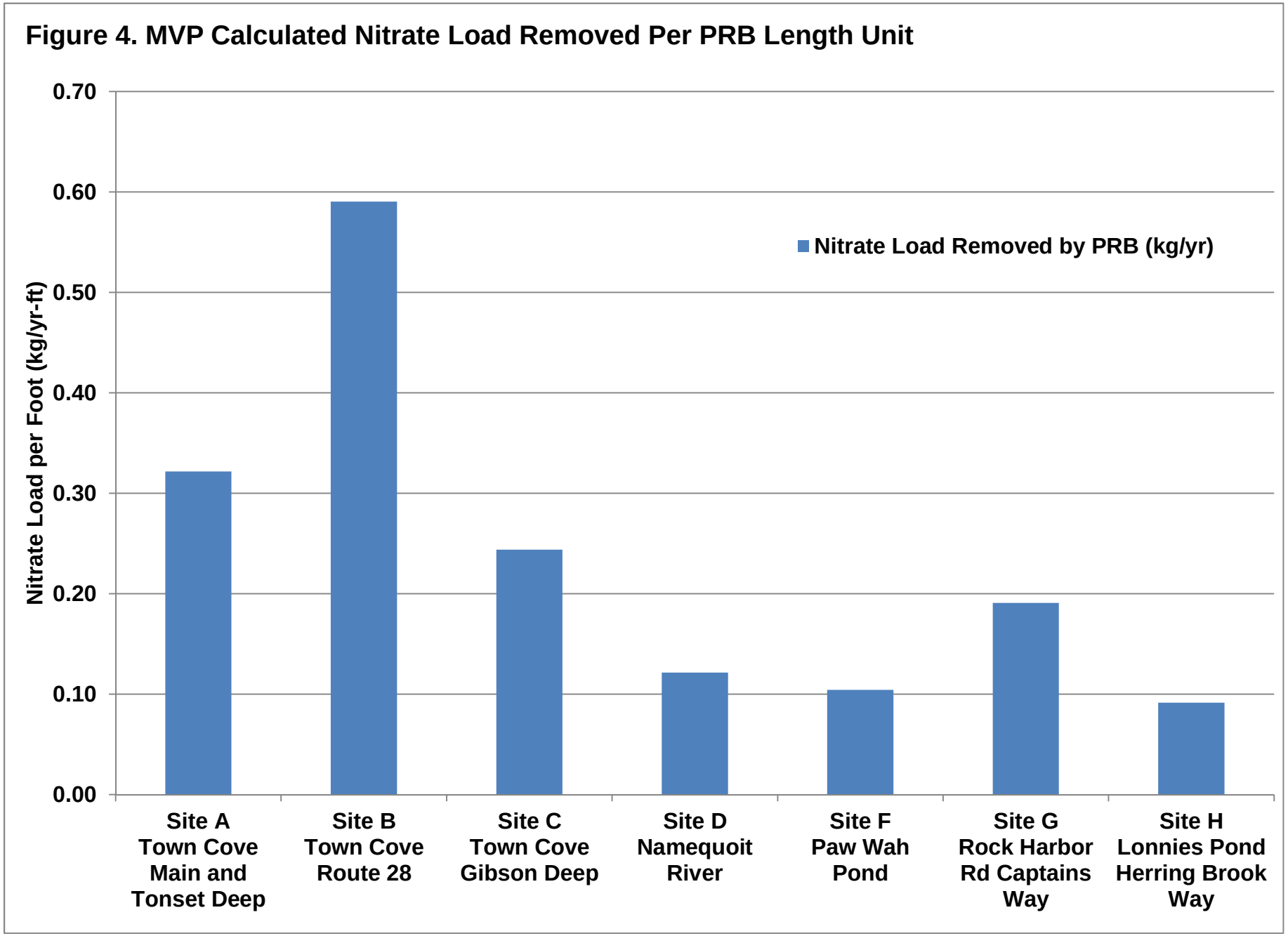


Table 1 WatershedMVP PRB Scenario Summary													
Scenario Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Description	Site A Town Cove Main and Tonset Deep	Town Cove Tonset Only	Town Cove Main St Only	Town Cove Main and Tonset Shallow	Site B Town Cove Route 28	Town Cove Gibson and Ruggles	Town Cove Ruggles 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

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 1 of 3	BORING NO. MW-A3-A
SITE LOCATION:Orleans, MA Groundwater Discharge Beds	JOB NO.: 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:	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	

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:	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	

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)*
5					0-5 ft - Vacum truck soft drilling of first 5 feet. Spoils used as backfill		2" well screen from 75' to 65'
10					5-9 ft. light to dark brown, coarse to medium SAND with trace silt		
15					9-13 ft. tan to brown, very coarse to medium SAND with trace silt		
					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 3 of 4	BORING NO. MW-E6-A
SITE LOCATION: Orleans, MA Groundwater Discharge Beds	JOB NO.: 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	

AECOM

GEOLOGIC LOG

PROJECT : Town of Orelans, MA Preliminary Investigation		SHEET	BORING NO.
SITE LOCATION: Orleans, MA	JOB NO.:	1 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)*
					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 2 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)*
					(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 3 of 3	BORING NO. MW-G1-A
SITE LOCATION: Orleans, MA Groundwater Discharge Beds	JOB NO.: 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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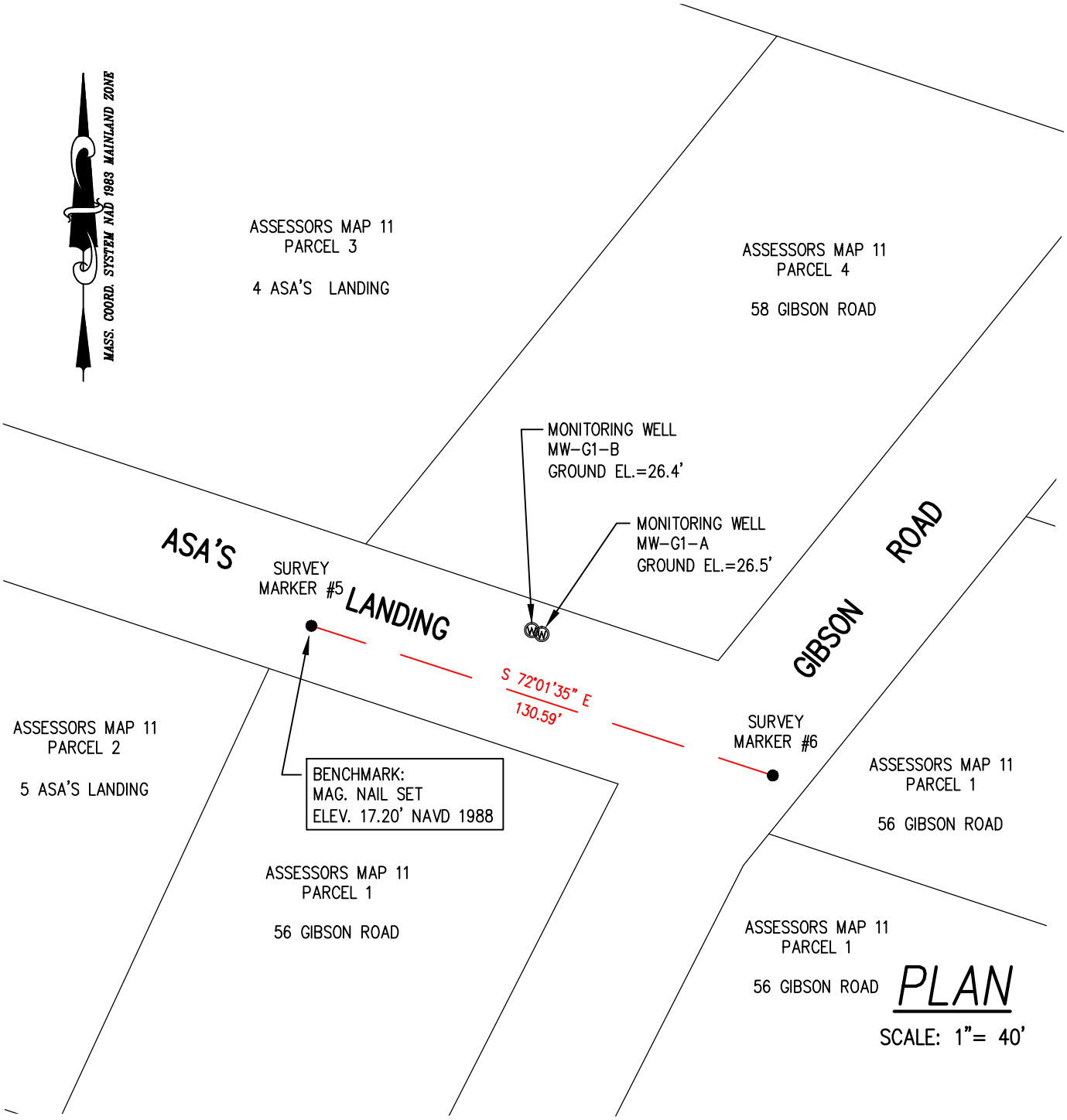

PLAN

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

DRAWN BY: JDM
C18470-00.dwg

COASTAL
engineering co.
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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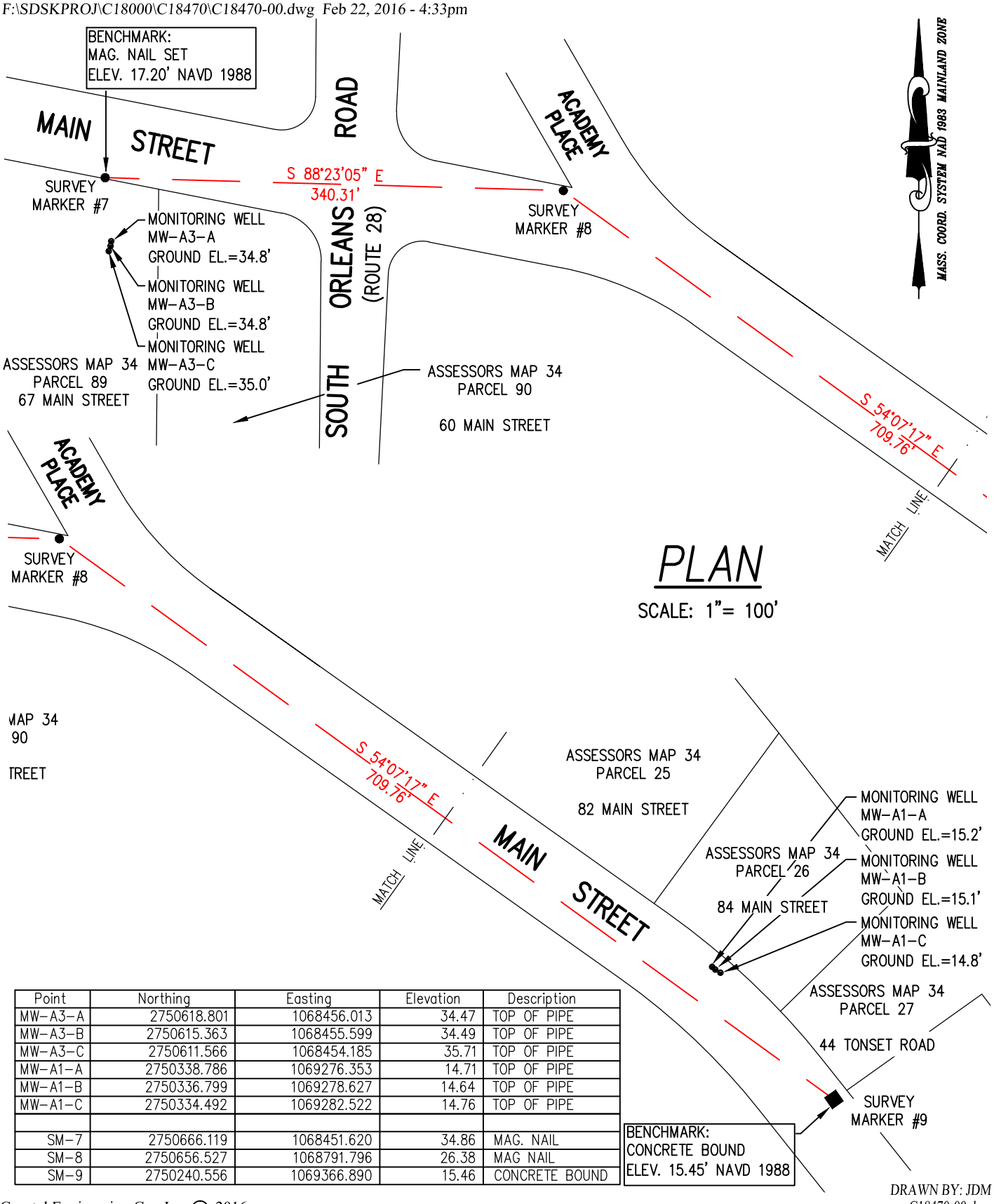

Point	Northing	Easting	Elevation	Description
MW-A3-A	2750618.801	1068456.013	34.47	TOP OF PIPE
MW-A3-B	2750615.363	1068455.599	34.49	TOP OF PIPE
MW-A3-C	2750611.566	1068454.185	35.71	TOP OF PIPE
MW-A1-A	2750338.786	1069276.353	14.71	TOP OF PIPE
MW-A1-B	2750336.799	1069278.627	14.64	TOP OF PIPE
MW-A1-C	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

DRAWN BY: JDM
C18470-00.dwg

COASTAL
engineering co.
260 Cranberry Hwy. Orleans, MA 02653
508.255.6511 P 508.255.6700 F

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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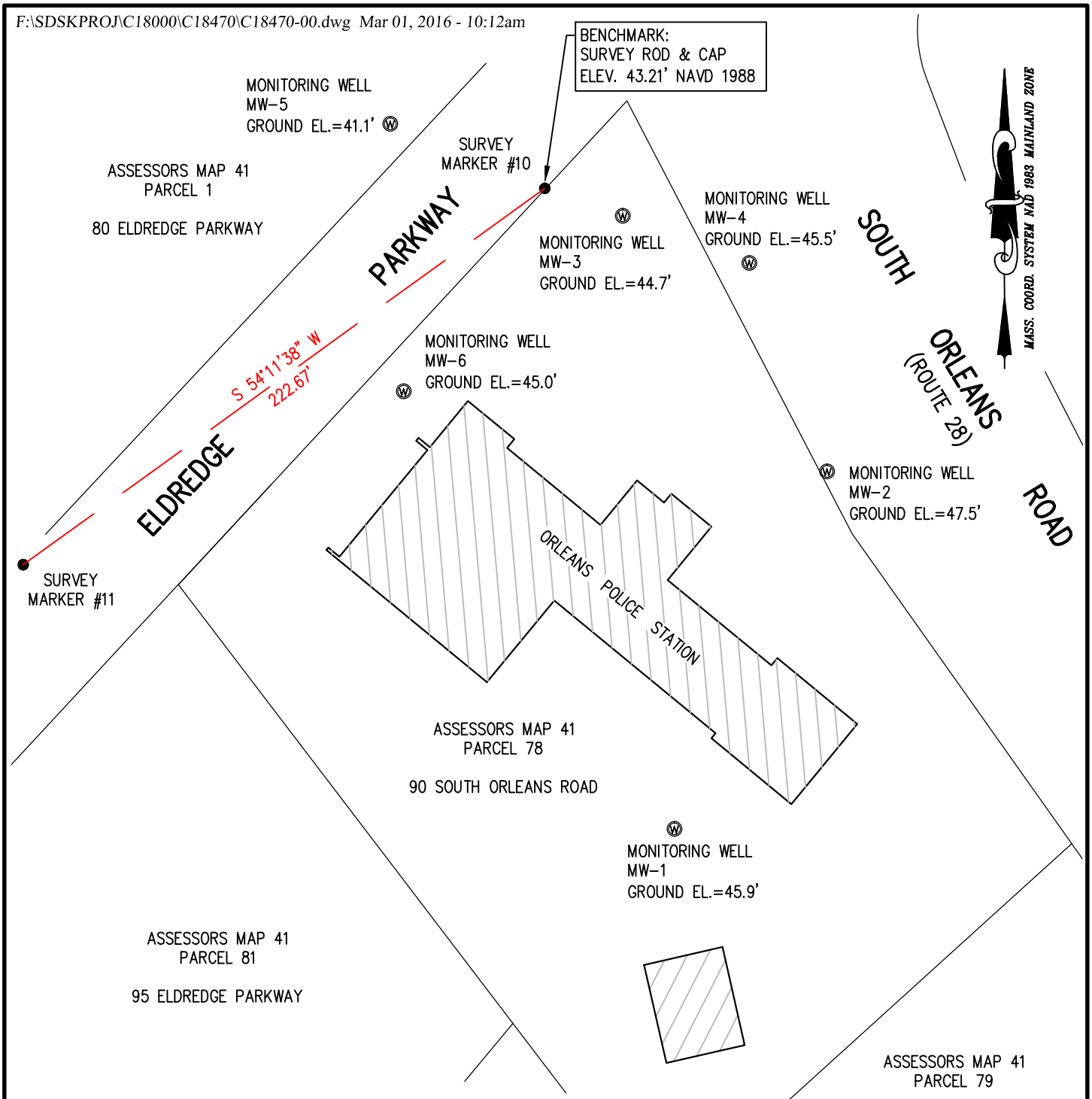

Point	Northing	Easting	Elevation	Description
MW-1	2748945.614	1068639.865	45.68	TOP OF PIPE
MW-2	2749069.380	1068692.752	46.97	TOP OF PIPE
MW-3	2749157.860	1068622.003	44.20	TOP OF PIPE
MW-4	2749141.510	1068665.766	45.31	TOP OF PIPE
MW-5	2749189.718	1068541.490	40.74	TOP OF PIPE
MW-6	2749097.097	1068546.124	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'

DRAWN BY: JDM
C18470-00.dwg

COASTAL
engineering co.
260 Cranberry Hwy. Orleans, MA 02653
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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C18470-00.dwg
DRAWN BY: JDM

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

COASTAL engineering co.
260 Cranberry Hwy, Orleans, MA 02653
508.255.6511 P 508.255.6700 F

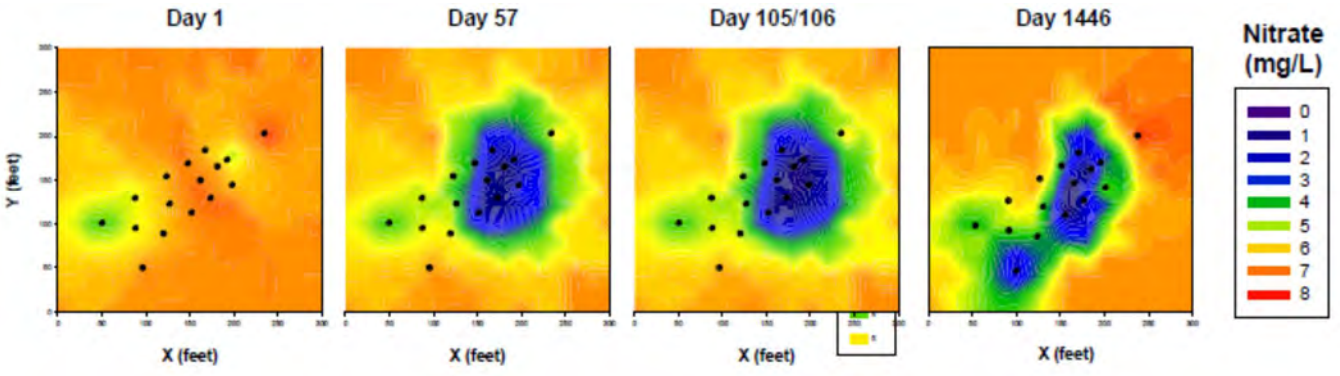
Appendix C

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.

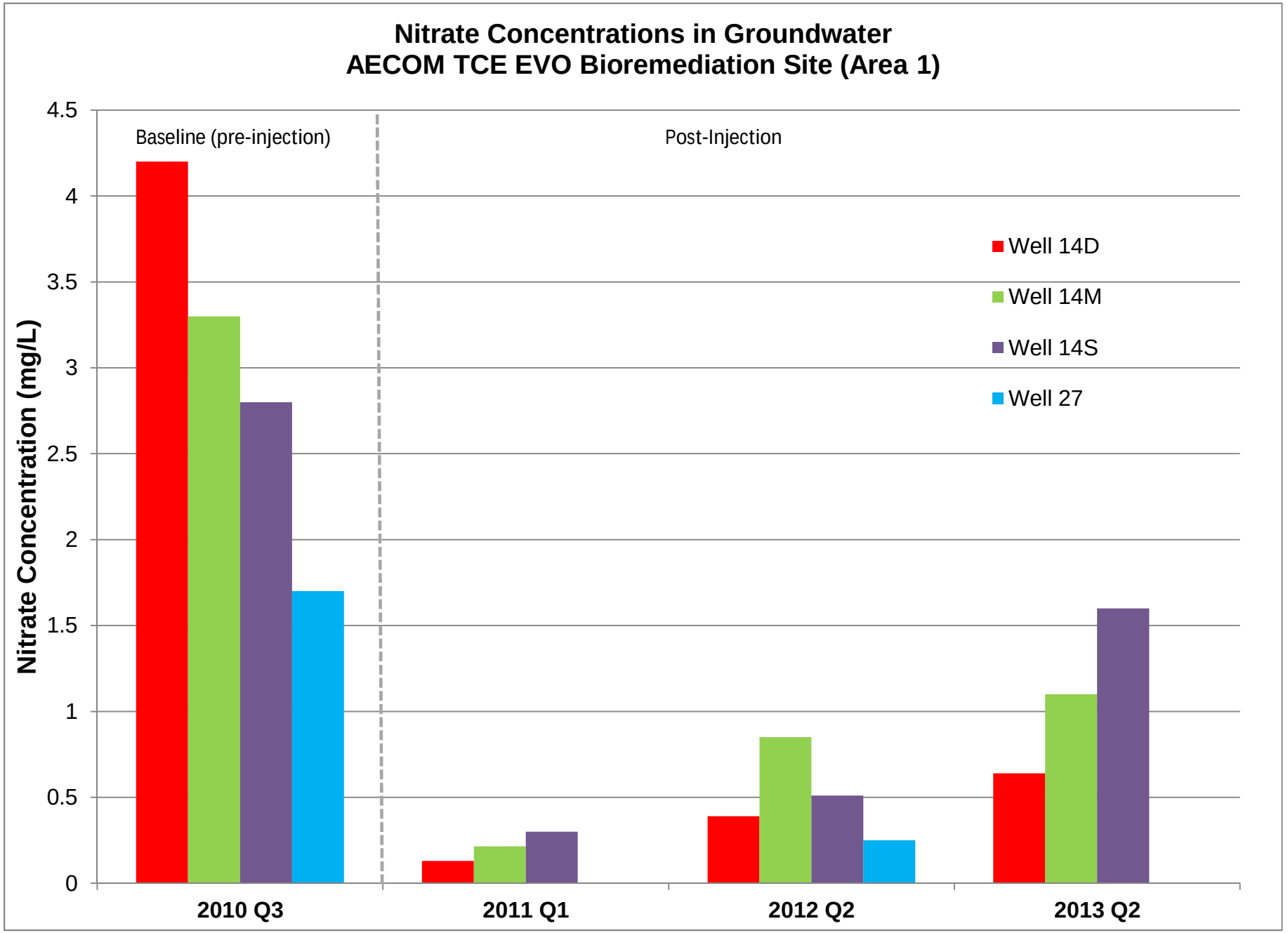


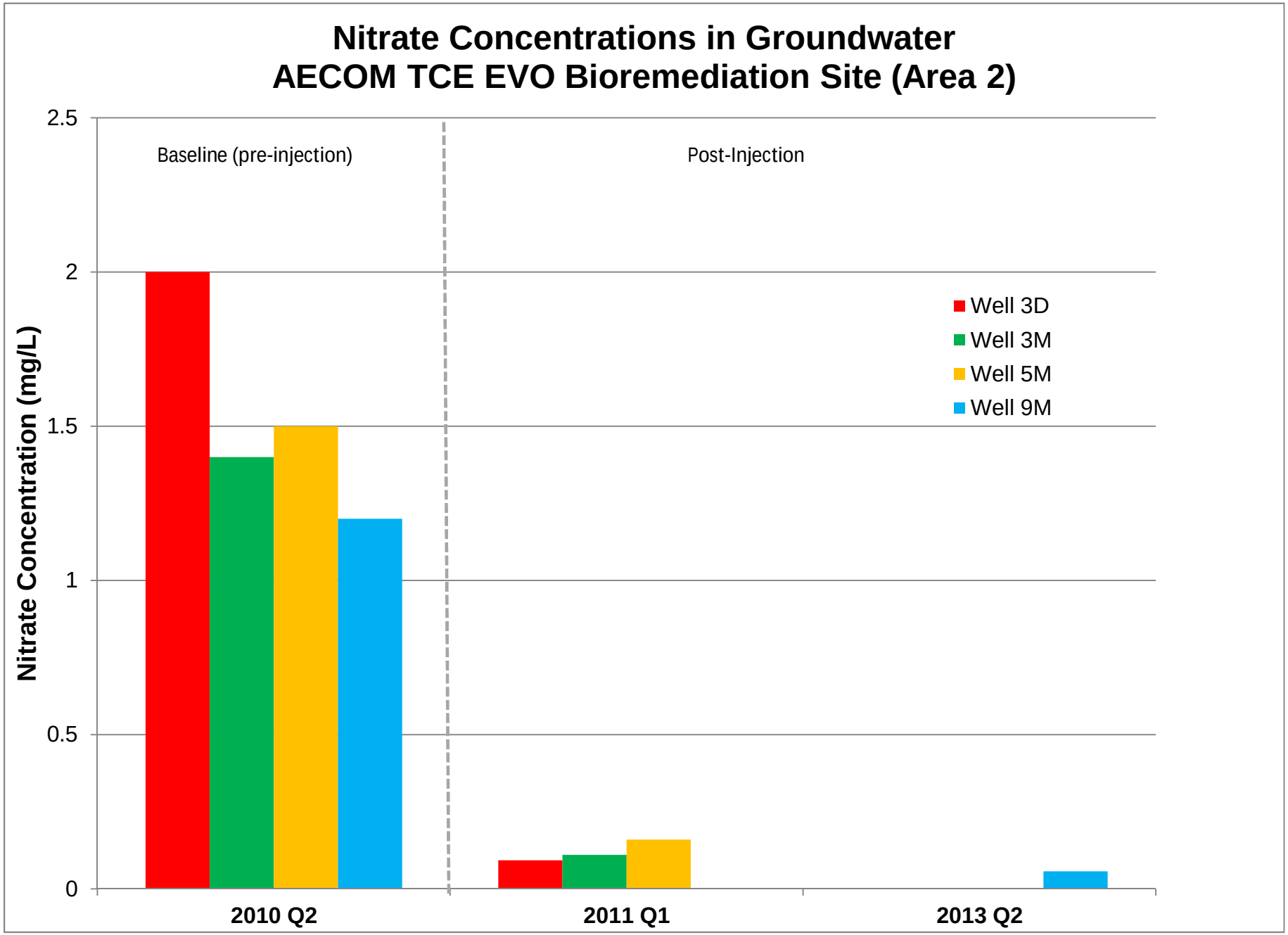
Time series of nitrate concentration after initial injection of food-grade carbon substrate (HRC)

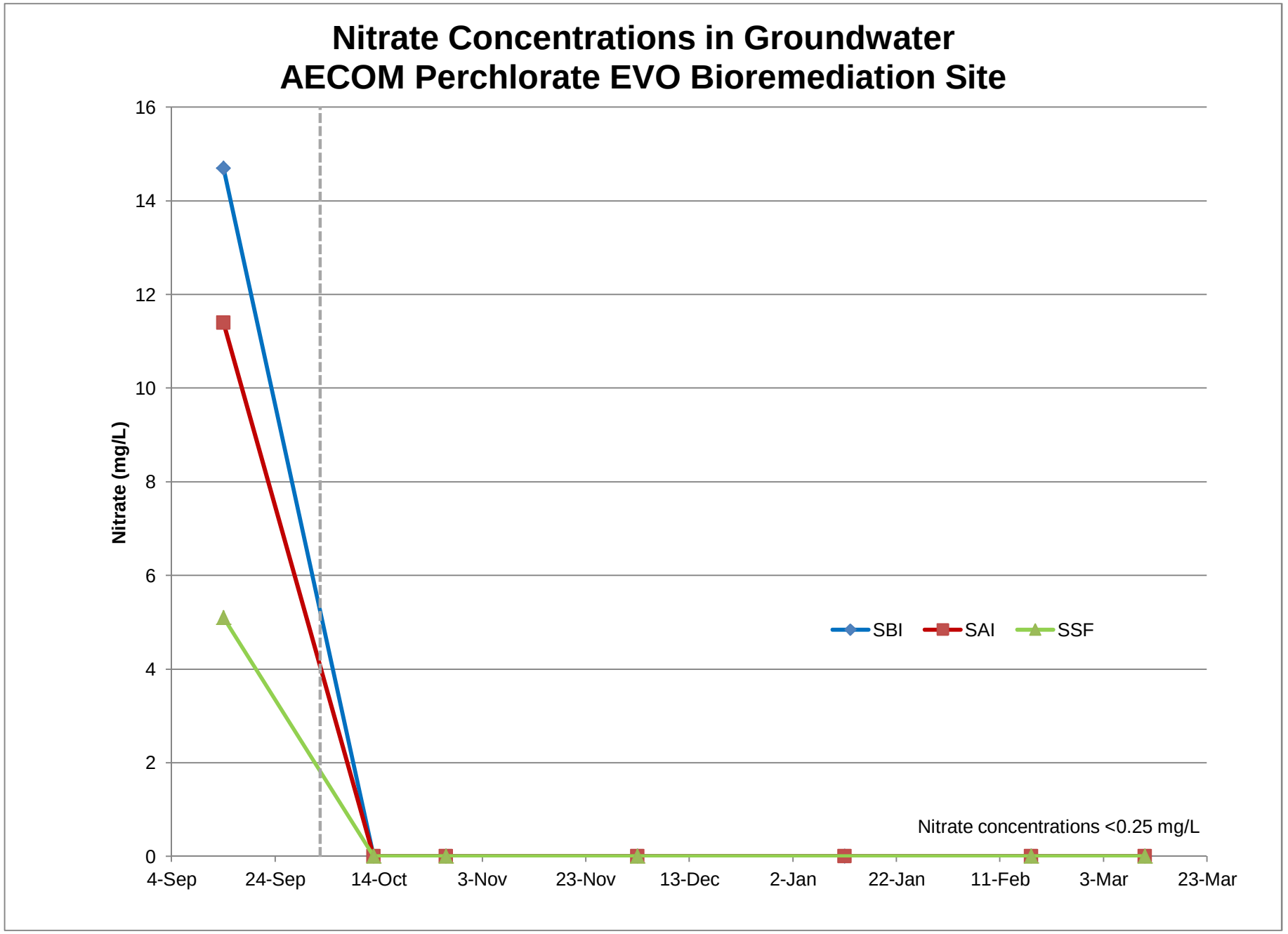
AECOM TCE EVO Bioremediation Site -

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 #

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 _____

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).

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	

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 | MA | 02653
City/Town | State | 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 | MA | 02653
City/Town | State | 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 #

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 #

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.

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

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

Source of injection fluid	Potential contaminants for Source
#1 Potable water (likely a hydrant)	#1 None
#2 Emulsified vegetable oil	#2 None
#3	#3
#4	#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

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

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.

BRP WS 06 UIC Registration

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

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

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

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)

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:	≥ 100C (≥ 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

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

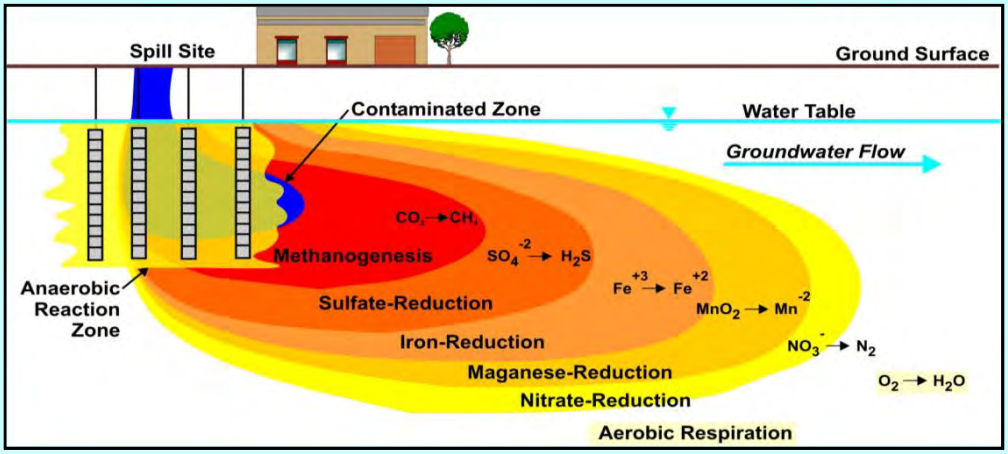


Table S.1 Input for Substrate Requirements in Hydrogen Equivalents

Site Name: PRB Demonstration Test - Landfill

RETURN TO COVER PAGE

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

^{o}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

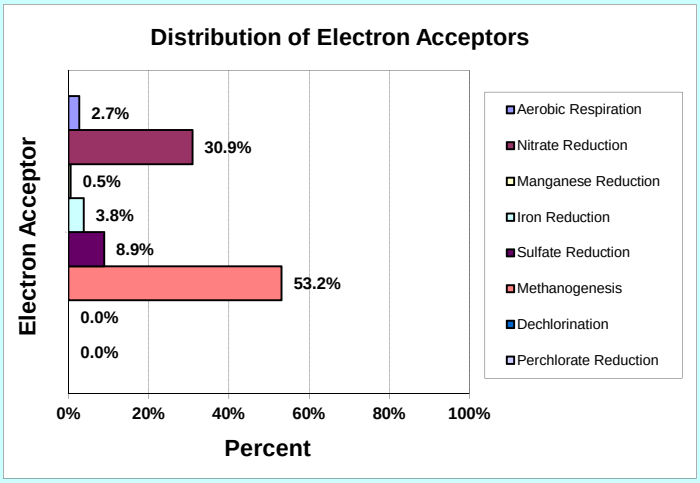
2. Treatment Zone Hydrogeologic Properties

	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

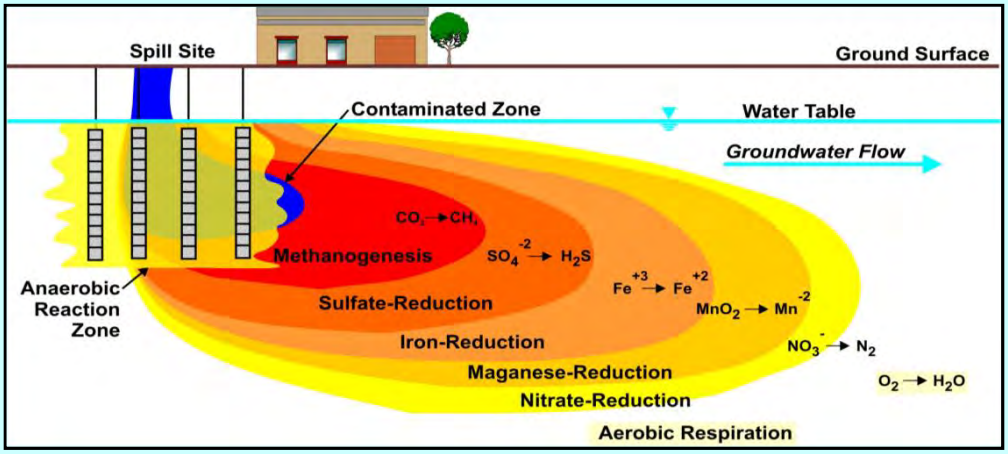


Table S.1 Input for Substrate Requirements in Hydrogen Equivalents

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

RETURN TO COVER PAGE

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

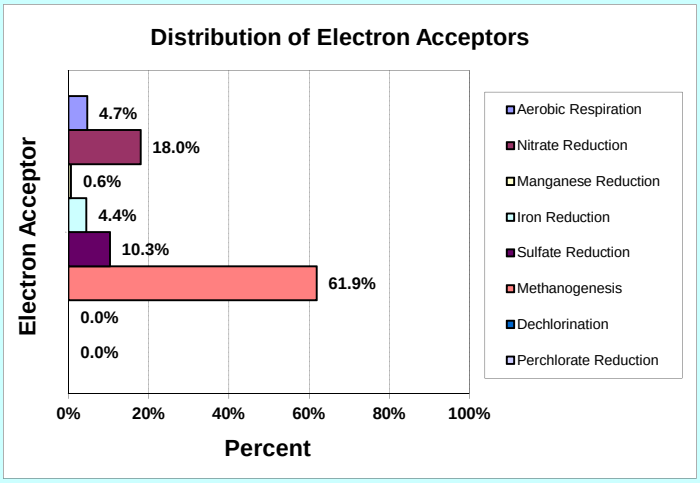
2. Treatment Zone Hydrogeologic Properties

	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 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
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	
								Field Filtered: Y / N	

BKM 02/03/16

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, Hardness	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	Bacteria				
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: ___ [ ] Pickup

Cooler Temperature: 5.3 - 1.0 = 4.3 2/11/16 [ ] 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 Backer 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

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	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			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 AECOM	Project #	Project Name	
Contact Person Mark Owen	Proj. Location ORLEANS		
Address 4 Jonathan Bourne DR	City, State Pocasset MA	Zip 02559	PO #
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	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

Please fax to the laboratory all changes to Chain of Custody

* By circling MA-MCP, client acknowledges sampels were collected in accordance with MADEP CAM VIIA

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.

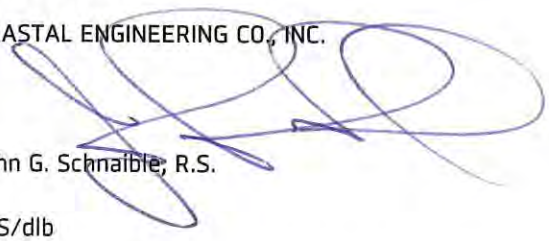
Date	Readings	Flow	Days (total)	School days	Gallons per day
12/12/12	2601800/4970120	198,750	63	42	4732*
1/7/13	2618200/4997580	43,860	26	12	3655*
3/26/13	2680800/5100940	165,960	78	55	3017*
6/18/13	2753100/5218470	189830	84	55	3451*
7/16/13	2761700/5239070	29,200	28	--	1043
9/25/13	2785600/5299280	84,110	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.



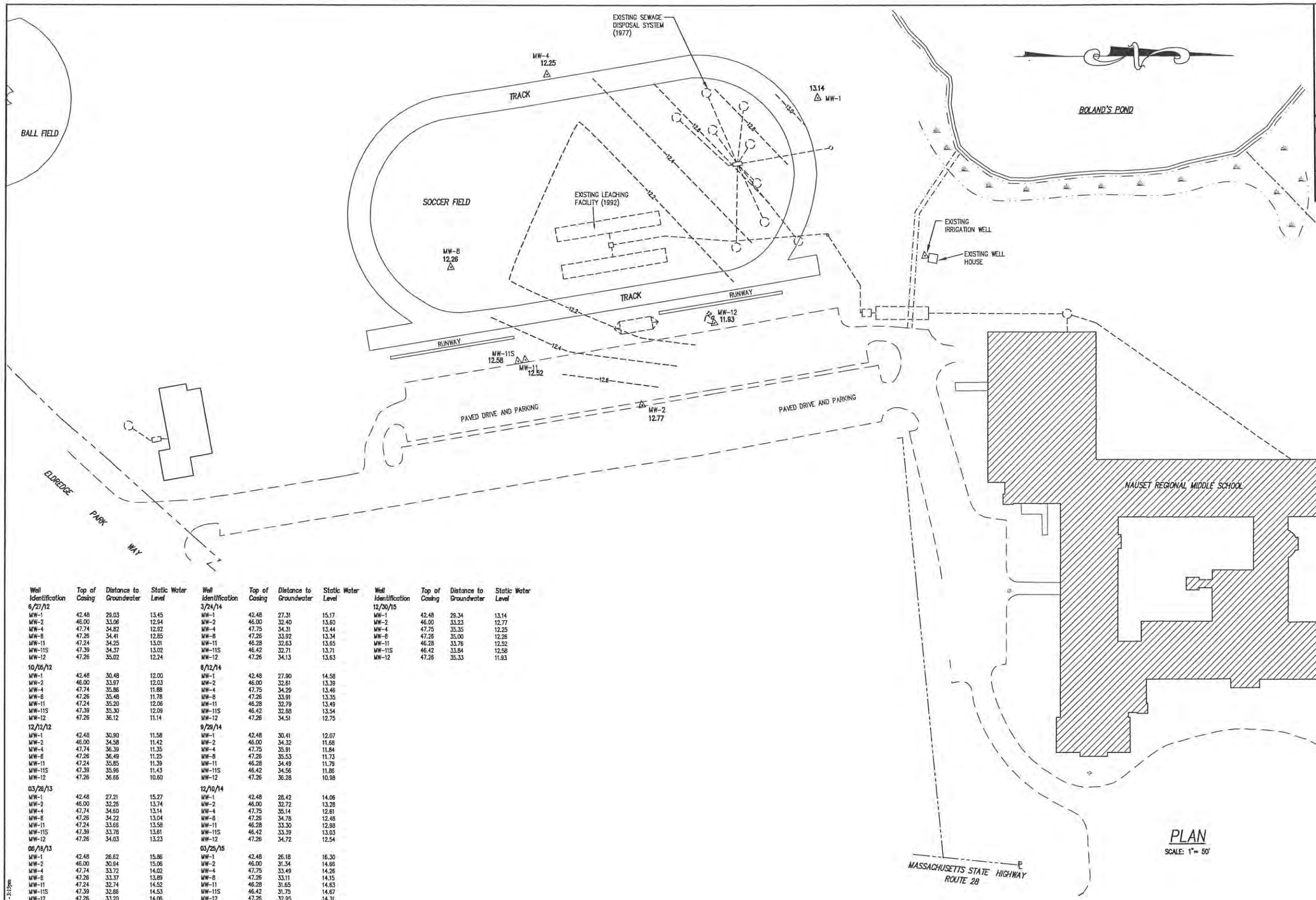
John G. Schnaible, R.S.

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
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
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

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

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.
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 #: 1512-28290

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
- 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

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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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Appendix C

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

s]Appendix C

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: Jonathan Lee
(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.

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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