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Memorandum

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Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 11.1.B – NT Demonstration Projects** **Task 11.1.B.2 - Technical Memorandum for Eldredge Park Permeable Reactive Barrier Demonstration Project – Q-3 September 2017 Groundwater Monitoring Quarterly Report - Final**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
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Approvals	Date	Signature / Initials
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1. Background

This purpose of this technical memorandum is to provide an update of quarterly groundwater monitoring results as part of the Eldredge Park Permeable Reactive Barrier (PRB) demonstration program. In addition to presenting baseline and quarterly groundwater monitoring data, this memorandum also summarizes monitoring well installation and emulsified vegetable oil (EVO) substrate injections for the Eldredge Park demonstration test site. AECOM Technical Services, Inc. (AECOM) PRB Technical Team (AECOM and MT Environmental Restoration) prepared this technical memorandum 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 reduce the nitrate load to impacted estuaries in the most cost effective manner 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. PRBs are a non-traditional 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 such as estuaries.

C. The results of the groundwater monitoring will be incorporated into an overall Adaptive Management Plan which will be implemented to evaluate the impacts of the technologies selected by the OWQAP on reducing nitrogen. AECOM will continue to work closely with the Town, its Water Quality Advisory Panel, and the regulatory agencies including the Cape Cod Commission (CCC) and MassDEP, in implementing the Adaptive Management Plan as it is critical to obtaining one of the first watershed permits granted by MassDEP.

D. The Demonstration Test aims to provide data to assess the cost effectiveness and applicability of PRBs as a treatment alternative for the Town. It is expected that the test 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 EVO substrate into the subsurface soils;

2) Establish and maintain necessary dissolved organic carbon concentrations and anaerobic (reducing) conditions in the groundwater while maintaining groundwater flow throughout the targeted treatment area;

3) Demonstrate reduced nitrate concentrations and the mass of nitrate transported in groundwater (nitrate flux) through groundwater monitoring;

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

5) Evaluate the life expectancy of the EVO and 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 to meet nitrate reduction targets.

3. Summary of Demonstration Test – Monitoring Well Installation

A. Summary of Past Monitoring Well Installation Activities

1) 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, as described in the PRB Work Plan (AECOM dated May 19, 2016). The Eldredge Park Demonstration Test site is located in the parking lot area between the Nauset Middle School playing fields and the Town-owned Eldredge Park baseball field. The demonstration site is owned by Nauset Public Schools. The Nauset Regional School Committee granted permission to install monitoring wells and conduct the PRB Demonstration Test at this location. Town Cove is located approximately 2,400 feet to the northeast of the Eldredge Park PRB Demonstration Test site. Groundwater in this area generally flows in a northeasterly direction, toward Town Cove (Figure 1).

2) Existing 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 treatment facility's leaching fields. An irrigation well for Eldredge Park was also identified near the corner of Eldredge Park and South Orleans Road with an available boring log and groundwater quality data.

3) In September 2016, four groundwater monitoring wells were installed in the selected demonstration test area. Water levels were measured and the groundwater flow direction was estimated. The orientation of the proposed PRB was modified before installing the remaining 19 groundwater monitoring wells in October 2016. All 23 groundwater monitoring wells were installed in order to allow for water quality measurement upgradient, downgradient, and cross-gradient of the demonstration PRB. One of the existing groundwater monitoring wells (MW-12) was also used as an upgradient well. Two wells (MW-12A and MW-12B) were installed at this location to monitor groundwater at deep and intermediate depths, respectively. The monitoring well network includes monitoring wells located along two transects (A to A' and B to B') oriented upgradient to downgradient in the direction of groundwater flow, perpendicular to the PRB layout. The location of all demonstration test monitoring wells can be seen on Figure 1. Cross-sections showing the multi-level monitoring well screen intervals along transects are presented in Figure 2 and Figure 3.

4) In March 2017, four additional groundwater monitoring wells were installed in order to expand the range of monitoring. A deep well (MW-B2075A) was installed at MW-B2100C (formerly referred to as MW-2100), which previously only had a shallow well. This will allow for a better understanding of the impact of the PRB injections at depth. MW-BC2B is an intermediate well that was installed approximately 50 feet east of MW-B2050A/B/C. This is a cross-gradient well that will provide a better understanding of the groundwater flow direction in this area.

   MW-BX1B and MW-BX1C are intermediate and shallow wells, respectively, that were installed approximately 20 feet northwest of where EVO was injected during the November 2016 demonstration injection activities. The purpose of installing these two wells is to better understand the groundwater flow pattern across the site and the source of high concentrations or nitrate noted north of the PRB. Previous surfer plot data (summarized in the Technical Memorandum for Eldredge Park Permeable Reactive Barriers Demonstration Overview of Baseline Sampling, Injection Activities, and Post-Injection Groundwater Monitoring (AECOM, March 2017)) indicates that the shallow wells may be impacted by flow from the northwest to southeast. The infiltration of stormwater through stormwater leaching basins located under the Middle School parking lot also may be impacting groundwater flow and will continue to be monitored via these wells during the remainder of the demonstration test monitoring program.

B. Summary of Additional Monitoring Well Installation Activities

1) There have been no additional monitoring wells installed since the February 2017 quarterly monitoring report was submitted in June 2017.

C. Summary of Topographic Survey Activities

1) Monitoring wells were surveyed by Coastal Engineering for location and top of PVC casing elevation to the nearest 1/100 foot. Top of PVC casing elevations are included in Table 1, and the well coordinates are included in Appendix A.

2) The screen intervals were typically 40 to 50 feet bgs in shallow "C" wells, 55 to 65 feet bgs in intermediate "B" wells, and 70 to 80 feet bgs in deep "A" wells. The depths to groundwater from the top of well casings were used to determine groundwater elevations and estimate the local direction of groundwater flow. The depth to groundwater ranged from approximately 30 to 35 feet bgs. Groundwater elevation data is included in Table 2. Field parameters and analytical results from monitoring well samples are shown in Table 3.

D. Summary of Groundwater Flow Direction

1) Groundwater contours generally indicate regional flow to the northeast through the PRB with local variations in direction in shallow and deeper groundwater. Groundwater flow appears to change to a more southeasterly flow immediately north of the PRB.

2) Variations in local flow direction may be associated with heterogeneities in the aquifer material (i.e. finer silts and clays vs. coarser sands), and other factors including Boland Pond, stormwater recharge through stormwater leaching basins, and wastewater recharge from the Nauset Regional Middle School system located under the soccer field. Groundwater elevation and flow direction data will be monitored over the remainder of the Demonstration Test.

4. Summary of Demonstration Test – Carbon Substrate Injection

A. PRB Treatment Process Description

1) PRBs are a passive treatment technology, designed in this application to intercept and treat nitrate in groundwater through 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 are designed not to interfere with groundwater flow.

2) The PRB in-situ (in place in the ground) treatment method typically introduces a carbon food substrate into the aquifer, allowing naturally occurring microbes in the aquifer 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). / Nitrate is the preferred electron acceptor to soil microbes after dissolved oxygen in the groundwater 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: $NO_3^- \rightarrow NO_2^- \rightarrow NO + N_2O \rightarrow N_{2\,(g)}$

B. Demonstration Test Layout

The current PRB Demonstration test is oriented northwest to southeast (perpendicular) to the northeasterly regional groundwater flow direction and is approximately 110 feet long. Future full-scale PRBs or sections or PRBs are anticipated to be longer (500 to 3,000 feet, depending on the location). Demonstration Test locations are shorter in length, selected to assess construction/implementation, and allow adequate monitoring of groundwater conditions in the vicinity of the PRBs to monitor the demonstration. A vertical treatment interval from the top of the groundwater table to approximately 35 feet into the saturated soils was selected for this Demonstration Test PRB.

C. Reactive Amendment Application Method

PRBs have been designed and implemented through several construction methods. During this demonstration test, direct-push methods were used place the EVO substrate in the subsurface. Direct–push injection is a method of soil boring modified with a down-hole injection screen and tubing used for placement of organic carbon electron donor EVO substrate. The direct-push injections are temporary injection points that are sealed following injection.

D. PRB Demonstration Test Substrate and System Details

An EVO solution with a larger droplet size was selected so that the EVO droplets will adhere to sand grains in the formation to minimize the advection, or distribution, of EVO after injection. EVO adheres to the sandy aquifer material in the treatment zone and provides a slow release of soluble organic carbon compounds that are distributed by advection, dispersion, and diffusion in groundwater. A larger droplet size will also maximize the persistence of the carbon substrate within the PRB. For this demonstration test, Terra System's 60 percent Large Droplet Slow Release EVO for Nitrate Reduction (SRS-NR) was used. The SRS NR is a modified formulation developed so that the emulsion is "stickier" in order to reduce migration after injection and increase persistence. Injecting EVO diluted with water enhances the distribution of EVO in the subsurface. The 60 percent EVO was

mixed with water making a 15.5 percent solution for injection. Product information, including the Material Safety Data Sheets (MSDS) for EVO substrate was presented in Appendix B of the *Technical Memorandum for Eldredge Park Permeable Reactive Barriers Demonstration Overview of Baseline Sampling, Injection Activities and Post-Injection Groundwater Monitoring – Final (AECOM, March 2017)*.

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 material must be applied to establish nitrate reducing conditions in the PRB. Calculations supporting amendment dosages were presented in Appendix C of the *Technical Memorandum for Eldredge Park Permeable Reactive Barriers Demonstration Overview of Baseline Sampling, Injection Activities and Post-Injection Groundwater Monitoring – Final (AECOM, March 2017)*. 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 Test, the EVO dosage was determined primarily to meet the electron donor demand based on site conditions including expected nitrate concentrations. Actual quantities of EVO used to establish the Demonstration Test treatment zone are summarized in Table 4-1 and can be seen on the injection field reports shown in Appendix D of the *Technical Memorandum for Eldredge Park Permeable Reactive Barriers Demonstration Overview of Baseline Sampling, Injection Activities and Post-Injection Groundwater Monitoring – Final (AECOM, March 2017)*.

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. Groundwater pH is typically between pH 5.5 and pH 6 across Cape Cod. Denitrifying bacteria are most active in circumneutral groundwater (pH 6 to 8). Based on groundwater data indicating a lower pH (5.5-6.5) at the site, sodium bicarbonate was used as a pH buffer with the EVO. Approximately 10.3 pounds of sodium bicarbonate was added per 300-gallons of EVO solution.

Table 4-1 - Summary of Design Parameters for Permeable Reactive Barrier Demonstration Test

Parameter	Demonstration Test Site
Area Description	Parking lot between the playing fields off Eldredge Park
Depth to Ground Water	30 to 40 feet below grade
Demonstration Test PRB Length	110 feet
Injection Interval	38 to 68 feet below grade
Injection Point Spacing	10 feet
Injection Points	17
Injection Pore Volume	12 percent (assumed effective porosity of 25 percent)
Total Injection Volume (gal)	10,800
Injection Volume Per Point (gal)	600 (Three points received 720, 820, 860 gal in order to use the remainder of the EVO.)
EVO Dilution	15.5 percent (~3.9:1 dilution from 60 percent EVO delivered)
Total EVO (gal)	2,620 (60 percent soy bean oil)

E. Substrate Delivery Record

Isotec, Inc. performed the injections on November 15 through 18, 2016 with oversight by the AECOM PRB Team. Injection of carbon substrate was performed directly through direct-push (i.e., GeoProbe®) rods, configured in 4-foot or 8-foot intervals with thin, laser cut injection holes. During the Demonstration Test, there were few geological limitations observed. The majority of the EVO was injected successfully with wellhead/injection pressure reading of 0 psi indicating no measureable resistance to injection. Several wells had higher wellhead pressures, close to 20 psi, particularly at their deepest intervals (56 to 68 feet). The higher pressure may indicate injection into lower permeability material such as finer sand and silt. All wellhead pressure observations can be seen on the daily injection reports in Appendix D of the *Technical Memorandum for Eldredge Park Permeable Reactive Barriers Demonstration Overview of Baseline Sampling, Injection Activities and Post-Injection Groundwater Monitoring – Final (AECOM, March 2017)*. The 17 injection points were spaced approximately 10 feet apart. The western side of the PRB consisted of seven points, spaced 10 feet apart. In order to assess the effect of injection point density and injection volume, the eastern side of the PRB consisted of 10 points configured in two parallel, offset lines of five points each. The five points were spaced approximately 10 feet from each other. The second line was five feet downgradient and off-set by five feet. Injection locations are depicted on Figure 1.

F. Field Injection Activities

The system for preparation, mixing, and injection of substrate solutions consisted of mixing tanks, mixers, pumps, piping, meters, valves, and fittings. All components were selected from materials that are compatible for use with the selected amendments. Injection batches were prepared in 300-gallon plastic tanks by adding appropriate quantities of water to achieve the selected dilution concentration. Mobile above-ground pumps and hoses were used to convey EVO directly to the injection points. Flow totalizers, pressure gauges, and shut-off valves were used to monitor injection pressure, flow rates, and total volume added to each injection interval at each injection point.

At each injection point, a direct-push drill rig advanced injection tooling to a targeted depth of 68 feet below grade. Seventy-five gallons of the diluted EVO solution were injected per four-foot interval. Both 4-foot and 8-foot injection points were used for injection. -The injection rods were lifted up four (or eight) feet to the subsequent injection target depth and the process was repeated. This method of direct-push injection is referred to as bottom-up injection. To minimize mounding and improve delivery, injection was generally not performed at adjacent points at the same time. A field log was maintained to record the solution composition, volume of solution delivered to each injection interval at injection point, length of time required for injection, and the injection pressure. Electricity to power remediation equipment was provided by a gasoline-powered generator. Potable water for batching and injection was collected from a nearby hydrant.

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) was filed with MassDEP under the category “Aquifer Remediation.” Similar injections of carbon substrates to enhance biodegradation of chemicals in groundwater have been commonly implemented in Massachusetts. 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 PRB complied with the requirements of the Massachusetts UIC regulations and the MCP requirements, including all required monitoring. MassDEP issued UIC Registration ID# MAS41A224209-5B6 for the Demonstration Test.

6. PRB Demonstration Test Performance Monitoring Plan

A. General

Performance monitoring of the PRB Demonstration Test is being implemented to assess nitrate reduction, concentrations of biogeochemical indicators, and the distribution of the injected reagents. It is anticipated that the monitoring program will be frequently evaluated and modified to respond to observations, adjusting the monitoring as necessary. This section details the performance monitoring program.

Groundwater samples will be collected from selected monitoring wells in the Demonstration Test area. The monitoring well network includes multi-level monitoring wells upgradient and downgradient of the PRB. These wells are aligned in two transects in addition to cross gradient and more regional monitoring wells. The monitoring network plan view is presented on Figure 1 and PRB monitoring well cross sections are shown on Figure 2 and Figure 3. The monitoring wells upgradient and downgradient of the PRB will be used to evaluate changes to nitrate concentrations and groundwater quality based on PRB performance. Monitoring wells downgradient of the PRB are located at selected distances from the PRB along the transects to assess distance of emulsion travel, extent of reducing conditions for denitrification, potential for metals mobilization, and for collection of groundwater elevation data for flow direction and groundwater flow velocity monitoring.

B. Sampling Method, Frequency, and Analyses

Groundwater samples are collected using a submersible pump. Groundwater quality parameters measured in the field include pH, oxidation reduction potential (ORP), dissolved oxygen (DO), specific conductivity, temperature, and turbidity. Field parameters are monitored with the use of a multi-parameter probe in a flow-through cell. Samples are collected after field water quality parameters stabilize.

Groundwater samples were collected prior to EVO injection to provide a comparative baseline to evaluate performance of the Demonstration Test. Baseline groundwater samples were analyzed to determine pre-treatment concentrations of nitrate and other indicator parameters whose change will be indicative of the impact of the PRB. In addition, a synoptic water level event was conducted after additional monitoring wells were installed, but prior to the start of injections, to further assess the groundwater flow direction and gradient.

During injection activities, select groundwater wells were monitored for field parameters (pH, temperature, dissolved oxygen, oxidation-reduction potential, and conductivity). Additionally, the EVO vendor Terra Systems monitored the 10 foot and 20 foot downgradient monitoring wells using an in-well probe for these same parameters in order to observe any potential changes during injection. During the third full day of injections, select wells were sampled and analyzed for dissolved organic carbon (DOC) and alkalinity to estimate whether there had been any EVO migration. Generally DOC and alkalinity test results did not indicate EVO migration. Visual monitoring at test wells located 10 foot and 20 foot downgradient of injection points indicated sporadic observation of higher turbidity and what may have been dilute EVO during injection.

The first post-injection sampling event was a stand-alone sampling event approximately 7 weeks after the injections with samples collected on January 5, 2017 and January 10, 2017. It is anticipated that additional routine groundwater sampling will be performed quarterly for a period of three years. Primary objectives of the post-injection sampling will be to:

1) Assess potential reduction in nitrate concentrations in groundwater compared to baseline samples and/or wells upgradient of the PRB;
2) Identify distance traveled by EVO emulsion and DOC;
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 injection; 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 6-1 presents an overview of the Demonstration Test performance monitoring analyses and relevance to the PRB Demonstration Test. It is anticipated the monitoring program will be dynamic and continuously evaluated to adjust the selected monitoring parameters and frequency of monitoring based on data collected and observations.

Table 6-1 - 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 septic system leach fields and landfills.
TKN	Total Kjeldahl Nitrogen (TKN) is the total concentration of organic nitrogen and ammonia.
Total Nitrogen	Analyses provide a summation of all organic and inorganic nitrogen species in groundwater as a result of leach fields and landfill.
CENSUS-DNA (Denitrifying Bacteria)	Analysis quantifies relative abundance of denitrifying bacteria.
Metals (Fe, Mn, As)	Mobility of metals can be impacted by groundwater geochemistry changes, notably pH and ORP.
DOC	Dissolved Organic Carbon (DOC) is the limiting factor in enhancing denitrification-and is increased by injection of EVO. DOC tracks the area of influence of the PRB.
Sulfate	Sulfate will decrease with generation of sufficiently anaerobic conditions favorable for sulfate-reducing bacteria.
pH	Denitrification optimal pH (6.0 and 8.5). Groundwater pH can decrease as a result of fermentation of injected carbon substrates.
ORP	Oxidation-reduction potential (ORP) will decrease with generation of reducing conditions following injection of carbon substrate.
Chloride	Chloride concentrations indicate potentially infiltrating stormwater.
Alkalinity	Denitrification reactions generate alkalinity (3.57 mg of $CaCO_3$ for each mg of nitrate reduced).
Boron	Boron is present in laundry detergents and is an indicator of groundwater flow emanating from leach fields.

7. PRB Demonstration Test Performance Monitoring Results To Date

A. Baseline Groundwater Monitoring

Preliminary baseline groundwater monitoring samples were collected on October 4, 2016 at a total of six wells, including three previously existing wells that are part of the Nauset Middle School quarterly sampling plan. After additional PRB demonstration monitoring wells were installed, baseline groundwater monitoring sampling was conducted. This sampling occurred on November 3, 2016 and November 4, 2016, where a total of 21 groundwater samples were collected. Field parameters and analytical results are shown in Table 3. Overall, baseline sampling indicated nitrate concentrations ranging from 0.357 mg/L (MW-BU2A) to 37 mg/L (MW-1050A).

B. Monitoring during Injection Activities

During the demonstration injections, field parameters were monitored at select upgradient and downgradient wells. Overall, no distinct patterns between the field parameters (temperature, pH, dissolved oxygen, conductivity, and turbidity) were observed before, during, and immediately following the injections. Raw field data, as monitored by TerraSystems and AECOM, is included in Appendix D of the *Technical Memorandum for Eldredge Park Permeable Reactive Barriers Demonstration Overview of Baseline Sampling, Injection Activities and Post-Injection Groundwater Monitoring – Final (AECOM, March 2017)*.

Laboratory dilutions were completed by Terra Systems producing stock solutions of EVO at various dilutions to determine a reasonable correlation between turbidity and the estimated SRS-NR concentrations. Based on these dilutions and the turbidity measured, data suggests the potential for movement of the SRS-NR emulsion up to 20 feet from the injection at certain depths. However, the conductivity was variable and did not correlate to turbidity. Field visual observations did not indicate significant quantities of emulsion at the downgradient wells. There was potentially a dilute “milky” coloration to the groundwater at the 10 foot and 20 foot wells, however, these observations were soon followed by indications of “clearer” water. These observations support the target area distribution of EVO along the PRB. EVO was not observed following completion of injection indicating the injected material was stable and not migrating.

Groundwater samples were collected from seven wells on November 17, 2016 and analyzed for alkalinity and DOC. Alkalinity was measured as a potential indication of the pH buffer that was added with the injections and DOC was measured as a potential indication of the EVO. The alkalinity at the downgradient wells (MW-1010C, MW-1020C, MW-2010C, and MW-2020B) ranged from 11 to 20 mg/L, which is slightly higher than the upgradient and cross-gradient wells (MW-12C, MW-BC2C, and MW-BU2C), which ranged from 4 to 13 mg/L. DOC ranged from 0.576 to 0.852 mg/L and was similar for both upgradient/cross-gradient and downgradient wells.

C. Initial Post-Injection Sampling (7 weeks)

A total of 14 groundwater samples were collected from select wells on January 5, 2017 and January 10, 2017. The wells sampled included upgradient wells MW-12A/B/C and MW-BU2A/B/C, cross-gradient well MW-BC2C, and downgradient wells MW-B1010C, MW-B1020B/C, MW-B1050A, MW-B2020B/C, and MW-B2050A. MW-B2010C was unable to be sampled due to snow cover. Analytical data is presented in Table 3. Laboratory reports are included in Appendix E of the *Technical Memorandum for Eldredge Park Permeable Reactive Barriers Demonstration Overview of Baseline Sampling, Injection Activities and Post-Injection Groundwater Monitoring – Final* (AECOM, March 2017).

D. Quarterly Sampling

1) Q-1 February 2017

The first post-injection quarterly sampling event occurred on February 23, 2017 and February 24, 2017 (Q-1), where groundwater samples were collected from 21 monitoring wells and analyzed for nitrate, nitrite, ammonia, Total Kjeldahl Nitrogen (TKN), Total Nitrogen, chloride, sulfate, dissolved iron, dissolved manganese, boron, sodium, total alkalinity, and DOC. Field-measured parameters, such as water level, pH, temperature, DO, ORP, conductivity, and turbidity, were also measured. MW-12C was unable to be sampled due to damage during snow removal at the site. Additionally, water levels were collected for six monitoring wells outside of the core monitoring well network.

The four additional monitoring wells that were installed in March 2017 were sampled in late March 2017 as part of the first round of quarterly sampling. Results of the laboratory analysis are included in this technical memorandum. Laboratory reports for the quarterly sampling event are included in Appendix B.

The expected lag time from PRB injection to measurable nitrate reduction in groundwater immediately downgradient of the barrier is two to four months. During this time the EVO begins to increase DOC concentrations, stimulating biological activity, which leads to an increase in the biomass of desired nitrate reducing bacteria.

The February samples were collected approximately three months post injection. Groundwater sample locations closest to the PRB (MW-B1010C and MW-B2010C) are located approximately ten feet downgradient of the injection zone (Figure 1). The February Quarter-1 (Q-1) sample at MW-B1010C indicated an increase in DOC from less than 1 mg/L during baseline sampling (November 2016) to 14 mg/L at Q-1. The MW-B1010C nitrate concentration decreased 27 percent from 13.6 at baseline to 9.94 mg/L at Q-1. Nitrate concentration data for baseline and quarterly sampling is included in Table 3 and on the cross-sections shown in Figure 4 and Figure 5.

Monitoring well MW-B2010C laboratory results also showed an increase in DOC concentrations. DOC increased from 2.2 mg/L at baseline to 19 mg/L at Q-1. Over the same period of time, the nitrate concentration decreased 68 percent from 15.7 to 5.06 mg/L.

Significant increases in DOC were not observed at other monitoring well locations and changes in nitrate concentration also did not appear to be significant with the exception of nitrate at monitoring well B1050A, where the nitrate concentration decreased 68 percent from 37 mg/L at baseline to 11.8 mg/L at Q-1.

No significant changes for dissolved iron and manganese were noted between the baseline and Q-1 sampling. Methane was not detected in groundwater at any of the locations sampled. These results indicate no significant impacts with respect to secondary water quality. No migration of EVO material was indicated by sampling observations or test results.

2) Q-2 June 2017

The second post-injection quarterly sampling (Q-2) event occurred on June 28, 2017 and June 29, 2017, approximately seven months post injection. This event was rescheduled from May due to the need to secure funding at the May Town Meeting. Additionally, there were several wet-weather events in May and it is recommended that sampling occur after several consecutive dry days to eliminate potential influences of the stormwater drains at the site.

During the June 2017 quarterly sampling event, groundwater samples were collected from 24 monitoring wells and analyzed for nitrate, nitrite, ammonia, Total Nitrogen, chloride, sulfate, dissolved iron, dissolved manganese, total alkalinity, and DOC. Field-measured parameters, such as water level, pH, temperature, DO, ORP, conductivity, and turbidity, were also measured. MW-12C has not been repaired from the damage during snow removal and was unable to be sampled. Additionally, water levels were collected from 9 monitoring wells outside of the core monitoring well network.

a) Assessment of Groundwater Flow Through the PRB June 2017

The PRB treatment line is composed of a series of injection points oriented northwest to southeast (perpendicular) to the northeasterly regional groundwater flow direction and is approximately 110 feet long. Depth to groundwater measurements at monitoring wells in the immediate vicinity of the PRB were completed prior to sampling during each monitoring event. The depth to water information was used to calculate water elevation and assess the direction of groundwater flow by developing contour maps of water level. Water elevation in shallow, intermediate depth, and deep wells were evaluated separately to assess flow direction at different depths.

Note that groundwater elevation can vary over time due to seasonal changes in groundwater recharge and can also change over the short term due to significant precipitation events. These changes can result in local variations in groundwater flow. Groundwater flow direction can also be in different directions at different depths below the water table, resulting in a complex 3-dimensional groundwater flow system. No significant rainfall was recorded between June 21, 2017 and June 29, 2017 at the nearby Chatham Municipal Airport prior to sampling.

As noted above, MW-BX1B and MW-BX1C are intermediate and shallow wells that were installed in March 2017 approximately 20 feet northwest of where EVO was injected during the November 2016 demonstration injection activities. The purpose of installing MW-BX1B and MW-BX1C was to gather more information to get a better understand the groundwater flow pattern across the site and help with the interpretation of observed nitrate concentrations. High nitrate concentrations had been noted along the monitoring transects east of the selected location for these new monitoring wells (e.g. at MW-B1020C, MW-B1050B, MW-B1050A, and MW-B2020B) shown on Figure 1. No similar high nitrate concentrations were observed in monitoring wells upgradient to the southwest of the PRB (e.g. MW-12A, MW-12B, and MW-12C).

Groundwater elevations calculated from the June 2017 data were interpolated to develop groundwater contour lines. The shallow groundwater data indicated a curved groundwater contour at elevation 12.3 as shown in blue on Figure 6. The resulting groundwater flow direction lines (black lines with arrows on Figure 6) show the groundwater flow pattern with partial flow through the PRB from southwest to northeast but also a significant flow from the northwest to southeast. Groundwater elevations and interpolated groundwater contours from the June 2017 data for intermediate depth (Figure 7) and deeper monitoring wells (Figure 8) indicated some variation but generally a similar pattern. Based on these flow directions, flow through the PRB does not appear to reach the full set of monitoring wells along the established monitoring well transects. Treated water may only be reaching the nearest monitoring wells on the north side and easterly of the PRB (e.g. MW-B1010C, MW-B2010C, MW-B2020B, and MW-B2020C). Monitoring wells along transects further to the north also appear to be affected by a local source of high nitrate concentration.

b) Assessment of Groundwater Chemistry Data

Groundwater sample locations closest to the PRB (MW-B1010C and MW-B2010C) are located approximately ten feet downgradient of the injection zone (Figure 1). The June Quarter-2 (Q-2) sample at MW-B1010C indicated an increase in DOC from 14 mg/L during Q-1 sampling (February 2017) to 17 mg/L at Q-2. Similarly, MW-B2010C indicated an increase in DOC from 19 mg/L during Q-1 to 83 mg/L during Q-2. The nitrate concentrations at MW-B1010C appear similar to baseline. The nitrate concentrations at MW-B2010C continued to show a concentration (5.7 mg/L) significantly below baseline (15.7 mg/L) and the oxidation-reduction potential (ORP) at MW-B2010C was negative, which indicates reducing conditions favorable to denitrification.

The DOC concentrations also increased slightly at the wells located approximately 20 feet from the injection points. MW-B1020B increased from 1.1 mg/L in Q-1 to 3.2 mg/L in Q-2, MW-B2020B increased from 1.0 mg/L in Q-1 to 3.5 mg/L in Q-2, MW-B2020C increased from 2 mg/L in Q-1 to 23 mg/L in Q-2.

Nitrate increased at MW-BX1B from 11.4 mg/L at Q-1 to 34.4 mg/L at Q-2, at MW-BX1C from 0.3 mg/L at Q-1 to 38.7 mg/L at Q-2. These high nitrate concentrations appear to be from a local source and are not within the target PRB treatment area.

Nitrate increased at MW-B1050A from 11.8 mg/L at Q-1 to 26.8 mg/L at Q-2, and at MW-B2020B from 14.8 mg/L at Q-1 to 22.4 mg/L at Q-2. While MW-B1050A and MW-B2020B both saw increases in nitrate concentrations, the shallow wells at those locations saw decreases in nitrate concentrations. Nitrate decreased at MW-B1050B from 28.7 mg/L at Q-1 to 18.2 mg/L at Q-2, at MW-B1050C from 4.0 mg/L at Q-1 to 3.3 mg/L at Q-2, and at MW-B2020C from 7.0 mg/L at Q-1 to 0.5 mg/L at Q-2.

Significant increases in DOC were not observed at other monitoring well locations and changes in nitrate concentration also did not appear to be significant. Nitrate concentration data for baseline and quarterly sampling is included in Table 3 and on the cross-sections shown in Figure 4 and Figure 5. Nitrate data are also included with groundwater contours and flow direction for shallow, intermediate depth, and deep groundwater monitoring wells on Figures 6, 7, and 8 respectively.

It was also noted that dissolved iron increased from 1.8 mg/L at Q-1 to 24.2 mg/L at Q-2 and dissolved manganese increased from 0.2 mg/L at Q-1 to 1.6 mg/L at Q-2 in MW-B2010C. Dissolved iron increased from <0.1 mg/L at Q-1 to 8.0 mg/L at Q-2 and dissolved manganese increased from 0.1 mg/L at Q-1 to 1.0 mg/L at Q-2 in MW-B2020C. These two locations are also where the significant increases in DOC were observed. The increases in iron and manganese are also indications of the reducing conditions favorable to denitrification. No significant changes for dissolved iron and manganese were noted between the Q-1 and Q-2 sampling at other locations. Methane was not detected in groundwater at MW-B1010C, but was present at 11.3 µg/L at MW-B2010C. This location demonstrated the highest increase in DOC and dissolved iron. No migration of EVO material was indicated by sampling observations or test results.

3) Q-3 September 2017

The third post-injection quarterly sampling (Q-3) event occurred on September 12, 2017 and September 13, 2017, approximately ten months post-injection. During the September 2017 quarterly sampling event, groundwater samples were collected from 24 monitoring wells and analyzed for nitrate, nitrite, ammonia, Total Nitrogen, chloride, sulfate, and DOC. Select groundwater samples were also analyzed for dissolved iron and dissolved manganese. Field-measured parameters, such as water level, pH, temperature, DO, ORP, conductivity, and turbidity, were also measured. MW-12C has not been repaired from the damage during snow removal during Winter 2016-2017 and was unable to be sampled. Additionally, water levels were collected from 6 monitoring wells outside of the core monitoring well network.

a) Assessment of Groundwater Flow Through the PRB September 2017

Groundwater elevations calculated from the September 2017 data were interpolated to develop groundwater contour lines (Figures 9, 10, and 11). The groundwater data indicated a similar pattern to the June 2017 contours. These data confirm that flow through the PRB does not appear to reach the full set of monitoring wells along the established monitoring well transects and treated water may only be reaching the nearest monitoring wells on the north side and easterly of the PRB. Monitoring wells along transects further to the north also appear to be affected by a local source of high nitrate concentration originating upgradient to the west of MW-BX1B and MW-BX1C.

b) Assessment of Groundwater Chemistry Data

Groundwater sample locations closest to the PRB (MW-B1010C and MW-B2010C) are located approximately ten feet downgradient of the injection zone (Figure 1). The September Quarter-3 (Q-3) sample at MW-B1010C indicated an increase in DOC from 16.9 mg/L during Q-2 sampling (June 2017) to 21.4 mg/L at Q-3. MW-B2010C indicated a slight decrease in DOC from 83.3 mg/L during Q-2 to 69.4 mg/L during Q-3, however, this is still elevated over the baseline DOC of 2.2 mg/L. The nitrate concentrations at MW-B1010C have decreased to 2.5 mg/L at Q-3 compared to 13.6 mg/L at baseline. The nitrate concentrations at MW-B2010C continued to show a concentration (0.18 mg/L) significantly below baseline (15.7 mg/L) and the oxidation-reduction potential (ORP) at MW-B2010C was negative (-119.80 mV), which indicates reducing conditions favorable to denitrification.

The DOC concentrations also increased slightly at almost all other monitoring wells. The largest of these increases was noted at MW-2020B, which increased from 3.5 mg/L in Q-2 to 29.8 mg/L in Q-3. MW-2020B also saw a significant decrease in nitrate concentration from 22.4 mg/L in Q-2 to 6.0 mg/L in Q-3. Nitrate concentrations decreased or remained about the same at all wells 20-feet downgradient.

Nitrate concentrations saw little to no change at most of the monitoring wells located 50 to 75 feet from the PRB along transect one. Nitrate concentrations decreased slightly at the three 50-foot wells on transect two, with the largest decrease at MW-B2050A, from 32.8 mg/L in Q-2 to 25.5 mg/L in Q-3. DOC also increased slightly at these three wells from ≤1.4 mg/L at Q-2 to ≥3.7 mg/L at Q-3.

Nitrate increased at MW-BX1B from 34.4 mg/L at Q-2 to 39.0 mg/L at Q-3. The concentration at MW-BX1C remained high at 37.8 mg/L. These high nitrate concentrations appear to be from a local source and are not within the target PRB treatment area.

Nitrate concentration data for baseline and quarterly sampling is included in Table 3 and on the cross-sections shown in Figure 4 and Figure 5. Nitrate data are also included with groundwater contours and flow direction for shallow, intermediate depth, and deep groundwater monitoring wells on Figures 9, 10, and 11 respectively.

Dissolved iron increased at MW-1010C from 0.14 mg/L in Q-2 to 3.88 mg/L in Q-3. There was not a major increase in dissolved manganese at this location. It was also noted that dissolved iron increased from 24.2 mg/L at Q-2 to 46.2 mg/L at Q-3 and dissolved manganese increased from 1.6 mg/L at Q-2 to 2.6 mg/L at Q-3 in MW-B2010C. Dissolved iron increased from 8.0 mg/L at Q-2 to 13.1 mg/L at Q-3 and dissolved manganese increased from 1.0 mg/L at Q-2 to 2.1 mg/L at Q-3 in MW-B2020C. The increases in iron and manganese are also indications of the reducing conditions favorable to denitrification. No significant changes for dissolved iron and manganese were noted between the Q-2 and Q-3 sampling at other locations where this was analyzed. No migration of EVO material was indicated by sampling observations or test results.

8. Summary, Schedule, and Coordination

In summary, the monitoring data indicated the presence of DOC from injected EVO at monitoring wells downgradient but only close to the north/northeast side of the PRB. Some of these monitoring wells showed reducing conditions favorable to denitrifying bacteria and significant reductions in nitrate concentrations over baseline conditions. However, the locally variable groundwater flow direction in the vicinity of the PRB prevents flow passing through the PRB from reaching monitoring wells further to the northeast along the transects. Groundwater flow reaching these transect monitoring wells also appears to be affected by a local source of high nitrate concentration. The Nauset Regional Middle School 1977 leaching pit wastewater disposal system which is currently in use is located below the north end of the soccer field in the area now known to be upgradient of these monitoring wells (Figure 12). A modification of the PRB system is necessary to improve the demonstration. This modification will require additional monitoring well installation to verify flow directions north of the PRB and establish an additional PRB injections zone starting at the west end of the current PRB injection zone and extending to the north approximately 110 feet roughly along the edge of the field and parking lot areas. The monitoring wells are necessary to verify groundwater contours for orientation of the new section of PRB perpendicular to the direction of groundwater flow.

Completed PRB Demonstration Test milestones include:

- PRB groundwater monitoring network installation;
- Baseline groundwater quality data collection and analysis;
- PRB construction with injection of EVO as planned;
- Initial post-injection water quality data collection and analysis; and
- First, second, and third post-injection quarterly monitoring data collection and analysis.

The current plan includes collecting quarterly samples for a period of three years. Periodic reporting will be conducted to share results and observations with the Town, regulatory agencies, and the public. The next quarterly monitoring event is expected to occur in January 2018.

9. References

AECOM – Technical Memorandum Final for Preliminary Engineering Work Plan for Permeable Reactive Barriers. Submitted to Town of Orleans, MA. May 19, 2016.

AECOM - Technical Memorandum for Eldredge Park Permeable Reactive Barriers Demonstration Overview of Baseline Sampling, Injection Activities and Post-Injection Groundwater Monitoring – Final. March 1, 2017.

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.

Terra Systems - Personal communications with Michael Lee, PhD, 2016.

10. List of Appendices

Appendix A – Monitoring Well Coordinates

Appendix B – Analytical Laboratory Reports

Tables

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Table 1 Orleans Monitoring Well Construction Details

Well ID	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	Location
MW-12A	45.6	45.57	80.0	70.0	80.0	-24.40	-34.40	-29.40	10.0	October 2016	Eldredge Park
MW-12B	45.6	45.58	65.0	55.0	65.0	-9.40	-19.40	-14.40	10.0	October 2016	Eldredge Park
MW-BU1A	43.7	43.48	80.0	70.0	80.0	-26.30	-36.30	-31.30	10.0	September 2016	Eldredge Park
MW-BU1C	44.0	43.65	50.0	40.0	50.0	4.00	-6.00	-1.00	10.0	September 2016	Eldredge Park
MW-BU2A	45.1	44.56	80.0	70.0	80.0	-24.90	-34.90	-29.90	10.0	October 2016	Eldredge Park
MW-BU2B	45.1	44.70	65.0	55.0	65.0	-9.90	-19.90	-14.90	10.0	October 2016	Eldredge Park
MW-BU2C	45.1	44.68	50.0	40.0	50.0	5.10	-4.90	0.10	10.0	October 2016	Eldredge Park
MW-BC1C	42.5	42.50	50.0	40.0	50.0	2.50	-7.50	-2.50	10.0	September 2016	Eldredge Park
MW-BC2C[1]	N/A	N/A	55.0	45.0	55.0	N/A	N/A	N/A	10.0	October 2016	Eldredge Park
MW-B1010C	44.9	44.46	55.0	45.0	55.0	-0.10	-10.10	-5.10	10.0	October 2016	Eldredge Park
MW-B1020B	44.6	44.18	65.0	55.0	65.0	-10.40	-20.40	-15.40	10.0	October 2016	Eldredge Park
MW-B1020C	44.5	44.10	50.0	40.0	50.0	4.50	-5.50	-0.50	10.0	October 2016	Eldredge Park
MW-B1050A	43.9	43.42	80.0	70.0	80.0	-26.10	-36.10	-31.10	10.0	October 2016	Eldredge Park
MW-B1050B	43.9	43.54	65.0	55.0	65.0	-11.10	-21.10	-16.10	10.0	October 2016	Eldredge Park
MW-B1050C	44.9	43.55	50.0	40.0	50.0	4.90	-5.10	-0.10	10.0	October 2016	Eldredge Park
MW-B1075B	43.5	43.29	65.0	55.0	65.0	-11.50	-21.50	-16.50	10.0	October 2016	Eldredge Park
MW-B2010C	45.0	44.70	55.0	45.0	55.0	0.00	-10.00	-5.00	10.0	October 2016	Eldredge Park
MW-B2020B	44.9	44.50	65.0	55.0	65.0	-10.10	-20.10	-15.10	10.0	October 2016	Eldredge Park
MW-B2020C	44.8	44.45	50.0	40.0	50.0	4.80	-5.20	-0.20	10.0	October 2016	Eldredge Park
MW-B2050A	44.6	44.06	80.0	70.0	80.0	-25.40	-35.40	-30.40	10.0	October 2016	Eldredge Park
MW-B2050B	44.6	44.28	65.0	55.0	65.0	-10.40	-20.40	-15.40	10.0	October 2016	Eldredge Park
MW-B2050C	44.6	44.17	50.0	40.0	50.0	4.60	-5.40	-0.40	10.0	October 2016	Eldredge Park
MW-B2075A	44.6	44.23	75.0	65.0	75.0	-20.40	-30.40	-25.40	10.0	March 2017	Eldredge Park
MW-B2100	44.6	44.23	45.0	35.0	45.0	9.60	-0.40	4.60	10.0	September 2016	Eldredge Park
MW-BC3	44.2	43.86	65.0	55.0	65.0	-10.80	-20.80	-15.80	10.0	March 2017	Eldredge Park
MW-BX1B	45.6	45.38	65.0	55.0	65.0	-9.40	-19.40	-14.40	10.0	March 2017	Eldredge Park
MW-BX1C	45.7	45.37	50.0	40.0	50.0	5.70	-4.30	0.70	10.0	March 2017	Eldredge Park

Notes:

N/A = Not Available

1. MW-BC2C has not yet been surveyed.

Table 2 Orleans Groundwater Elevations

Well ID	Location	Date	TOC Elevation (ft)	Depth to Water (ft)	GW Elevation (ft)
MW-1	Eldredge Park	11/3/2016	41.31	30.10	11.21
MW-1	Eldredge Park	11/14/2016	41.31	30.20	11.11
MW-1	Eldredge Park	1/18/2017	41.31	30.43	10.88
MW-1	Eldredge Park	1/27/2017	41.31	30.25	11.06
MW-1	Eldredge Park	2/24/2017	41.31	29.50	11.81
MW-1	Eldredge Park	4/25/2017	41.31	28.17	13.14
MW-1	Eldredge Park	6/29/2017	41.31	28.37	12.94
MW-1	Eldredge Park	9/13/2017	41.31	N/A	N/A
MW-11	Eldredge Park	11/3/2016	45.14	34.20	10.94
MW-11	Eldredge Park	11/14/2016	45.14	34.20	10.94
MW-11	Eldredge Park	1/18/2017	45.14	34.42	10.72
MW-11	Eldredge Park	1/27/2017	45.14	33.31	11.83
MW-11	Eldredge Park	2/24/2017	45.14	33.87	11.27
MW-11	Eldredge Park	4/25/2017	45.14	32.84	12.30
MW-11	Eldredge Park	6/29/2017	45.14	32.82	12.32
MW-11	Eldredge Park	9/13/2017	45.14	N/A	N/A
MW-11S	Eldredge Park	11/3/2016	45.25	34.15	11.10
MW-11S	Eldredge Park	11/14/2016	45.25	34.25	11.00
MW-11S	Eldredge Park	1/18/2017	45.25	34.51	10.74
MW-11S	Eldredge Park	1/27/2017	45.25	34.36	10.89
MW-11S	Eldredge Park	2/24/2017	45.25	33.93	11.32
MW-11S	Eldredge Park	4/25/2017	45.25	32.92	12.33
MW-11S	Eldredge Park	6/29/2017	45.25	32.90	12.35
MW-11S	Eldredge Park	9/13/2017	45.25	32.95	12.30
MW-12A	Eldredge Park	11/3/2016	45.57	34.40	11.17
MW-12A	Eldredge Park	11/14/2016	45.57	35.01	10.56
MW-12A	Eldredge Park	1/18/2017	45.57	34.71	10.86
MW-12A	Eldredge Park	1/27/2017	45.57	34.57	11.00
MW-12A	Eldredge Park	2/23/2017	45.57	34.16	11.41
MW-12A	Eldredge Park	4/25/2017	45.57	33.85	11.72
MW-12A	Eldredge Park	6/29/2017	45.57	33.17	12.40
MW-12A	Eldredge Park	9/12/2017	45.57	33.17	12.40
MW-12B	Eldredge Park	11/3/2016	45.58	34.50	11.08
MW-12B	Eldredge Park	11/14/2016	45.58	34.90	10.68
MW-12B	Eldredge Park	1/18/2017	45.58	34.79	10.79
MW-12B	Eldredge Park	1/27/2017	45.58	34.64	10.94
MW-12B	Eldredge Park	2/23/2017	45.58	34.24	11.34
MW-12B	Eldredge Park	4/25/2017	45.58	33.70	11.88
MW-12B	Eldredge Park	6/29/2017	45.58	33.21	12.37
MW-12B	Eldredge Park	9/12/2017	45.58	33.12	12.46
MW-12C (Existing)	Eldredge Park	11/3/2016	46.61	36.27	10.34
MW-12C (Existing)	Eldredge Park	11/14/2016	46.61	35.99	10.62
MW-12C (Existing)	Eldredge Park	1/18/2017	46.61	36.21	10.40
MW-12C (Existing)	Eldredge Park	1/27/2017	46.61	36.06	10.55
MW-12C (Existing)[1]	Eldredge Park	2/23/2017	46.61	36.30	10.31
MW-12C (Existing)[1]	Eldredge Park	4/25/2017	46.61	34.95	11.66
MW-12C (Existing)[1]	Eldredge Park	6/29/2017	46.61	34.79	11.82
MW-12C (Existing)[1]	Eldredge Park	9/13/2017	46.61	13.00	33.61

Table 2 Orleans Groundwater Elevations

Well ID	Location	Date	TOC Elevation (ft)	Depth to Water (ft)	GW Elevation (ft)
MW-2	Eldredge Park	11/3/2016	44.82	33.65	11.17
MW-2	Eldredge Park	11/14/2016	44.82	33.83	10.99
MW-2	Eldredge Park	1/18/2017	44.82	34.03	10.79
MW-2	Eldredge Park	1/27/2017	44.82	33.91	10.91
MW-2	Eldredge Park	2/24/2017	44.82	33.43	11.39
MW-2	Eldredge Park	4/25/2017	44.82	32.68	12.14
MW-2	Eldredge Park	6/29/2017	44.82	32.54	12.28
MW-2	Eldredge Park	9/13/2017	44.82	32.15	12.67
MW-4	Eldredge Park	11/3/2016	46.57	35.53	11.04
MW-4	Eldredge Park	11/14/2016	46.57	35.71	10.86
MW-4	Eldredge Park	1/18/2017	46.57	35.98	10.59
MW-4	Eldredge Park	1/27/2017	46.57	35.83	10.74
MW-4	Eldredge Park	2/24/2017	46.57	35.48	11.09
MW-4	Eldredge Park	4/25/2017	46.57	35.63	10.94
MW-4	Eldredge Park	6/29/2017	46.57	34.41	12.16
MW-4	Eldredge Park	9/13/2017	46.57	34.52	12.05
MW-8	Eldredge Park	October 2016	46.16	35.30	10.86
MW-8	Eldredge Park	11/14/2016	46.16	35.22	10.94
MW-8	Eldredge Park	1/18/2017	46.16	35.62	10.54
MW-8	Eldredge Park	1/27/2017	46.16	35.50	10.66
MW-8	Eldredge Park	2/24/2017	46.16	35.12	11.04
MW-8	Eldredge Park	4/25/2017	46.16	24.51	21.65
MW-8	Eldredge Park	6/29/2017	46.16	34.03	12.13
MW-8	Eldredge Park	9/13/2017	46.16	34.21	11.95
MW-B1010C	Eldredge Park	11/3/2016	44.46	33.60	10.86
MW-B1010C	Eldredge Park	11/14/2016	44.46	33.98	10.48
MW-B1010C	Eldredge Park	1/18/2017	44.46	33.97	10.49
MW-B1010C	Eldredge Park	1/27/2017	44.46	33.81	10.65
MW-B1010C	Eldredge Park	2/23/2017	44.46	33.25	11.21
MW-B1010C	Eldredge Park	4/25/2017	44.46	32.53	11.93
MW-B1010C	Eldredge Park	6/29/2017	44.46	32.15	12.31
MW-B1010C	Eldredge Park	9/12/2017	44.46	32.13	12.33
MW-B1020B	Eldredge Park	11/3/2016	44.18	33.42	10.76
MW-B1020B	Eldredge Park	11/14/2016	44.18	33.68	10.50
MW-B1020B	Eldredge Park	1/18/2017	44.18	33.81	10.37
MW-B1020B	Eldredge Park	1/27/2017	44.18	33.66	10.52
MW-B1020B	Eldredge Park	2/23/2017	44.18	33.18	11.00
MW-B1020B	Eldredge Park	4/25/2017	44.18	32.60	11.58
MW-B1020B	Eldredge Park	6/29/2017	44.18	32.14	12.04
MW-B1020B	Eldredge Park	9/12/2017	44.18	32.01	12.17
MW-B1020C	Eldredge Park	11/3/2016	44.10	33.16	10.94
MW-B1020C	Eldredge Park	11/14/2016	44.10	33.32	10.78
MW-B1020C	Eldredge Park	1/18/2017	44.10	33.53	10.57
MW-B1020C	Eldredge Park	1/27/2017	44.10	33.32	10.78
MW-B1020C	Eldredge Park	2/23/2017	44.10	32.80	11.30
MW-B1020C	Eldredge Park	4/25/2017	44.10	32.10	12.00
MW-B1020C	Eldredge Park	6/29/2017	44.10	31.71	12.39
MW-B1020C	Eldredge Park	9/12/2017	44.10	31.74	12.36
MW-B1050A	Eldredge Park	11/3/2016	43.42	32.84	10.58
MW-B1050A	Eldredge Park	11/14/2016	43.42	32.92	10.50

Table 2 Orleans Groundwater Elevations

Well ID	Location	Date	TOC Elevation (ft)	Depth to Water (ft)	GW Elevation (ft)
MW-B1050A	Eldredge Park	1/18/2017	43.42	32.91	10.51
MW-B1050A	Eldredge Park	1/27/2017	43.42	32.88	10.54
MW-B1050A	Eldredge Park	2/23/2017	43.42	32.54	10.88
MW-B1050A	Eldredge Park	4/25/2017	43.42	31.28	12.14
MW-B1050A	Eldredge Park	6/29/2017	43.42	31.42	12.00
MW-B1050A	Eldredge Park	9/12/2017	43.42	31.45	11.97
MW-B1050B	Eldredge Park	11/3/2016	43.54	32.65	10.89
MW-B1050B	Eldredge Park	11/14/2016	43.54	32.72	10.82
MW-B1050B	Eldredge Park	1/18/2017	43.54	32.98	10.56
MW-B1050B	Eldredge Park	1/27/2017	43.54	32.81	10.73
MW-B1050B	Eldredge Park	2/23/2017	43.54	32.28	11.26
MW-B1050B	Eldredge Park	4/25/2017	43.54	31.45	12.09
MW-B1050B	Eldredge Park	6/29/2017	43.54	31.21	12.33
MW-B1050B	Eldredge Park	9/12/2017	43.54	31.19	12.35
MW-B1050C	Eldredge Park	11/3/2016	43.55	32.80	10.75
MW-B1050C	Eldredge Park	11/14/2016	43.55	32.80	10.75
MW-B1050C	Eldredge Park	1/18/2017	43.55	33.02	10.53
MW-B1050C	Eldredge Park	1/27/2017	43.55	32.96	10.59
MW-B1050C	Eldredge Park	2/23/2017	43.55	32.40	11.15
MW-B1050C	Eldredge Park	4/25/2017	43.55	31.52	12.03
MW-B1050C	Eldredge Park	6/29/2017	43.55	31.21	12.34
MW-B1050C	Eldredge Park	9/12/2017	43.55	31.22	12.33
MW-B1075B	Eldredge Park	11/3/2016	43.29	32.55	10.74
MW-B1075B	Eldredge Park	11/14/2016	43.29	32.57	10.72
MW-B1075B	Eldredge Park	1/18/2017	43.29	32.78	10.51
MW-B1075B	Eldredge Park	1/27/2017	43.29	32.62	10.67
MW-B1075B	Eldredge Park	2/23/2017	43.29	32.10	11.19
MW-B1075B	Eldredge Park	4/25/2017	43.29	31.22	12.07
MW-B1075B	Eldredge Park	6/29/2017	43.29	30.98	12.31
MW-B1075B	Eldredge Park	9/13/2017	43.29	30.93	12.36
MW-B2010C	Eldredge Park	11/3/2016	44.70	33.95	10.75
MW-B2010C	Eldredge Park	11/14/2016	44.70	34.10	10.60
MW-B2010C	Eldredge Park	1/18/2017	44.70	34.41	10.29
MW-B2010C	Eldredge Park	1/27/2017	44.70	34.21	10.49
MW-B2010C	Eldredge Park	2/24/2017	44.70	33.77	10.93
MW-B2010C	Eldredge Park	4/25/2017	44.70	33.00	11.70
MW-B2010C	Eldredge Park	6/29/2017	44.70	32.67	12.03
MW-B2010C	Eldredge Park	9/13/2017	44.70	32.52	12.18
MW-B2020B	Eldredge Park	11/3/2016	44.50	33.90	10.60
MW-B2020B	Eldredge Park	11/14/2016	44.50	33.90	10.60
MW-B2020B	Eldredge Park	1/18/2017	44.50	34.15	10.35
MW-B2020B	Eldredge Park	1/27/2017	44.50	34.03	10.47
MW-B2020B	Eldredge Park	2/24/2017	44.50	33.50	11.00
MW-B2020B	Eldredge Park	4/25/2017	44.50	32.88	11.62
MW-B2020B	Eldredge Park	6/29/2017	44.50	32.45	12.05
MW-B2020B	Eldredge Park	9/13/2017	44.50	32.32	12.18

Table 2 Orleans Groundwater Elevations

Well ID	Location	Date	TOC Elevation (ft)	Depth to Water (ft)	GW Elevation (ft)
MW-B2020C	Eldredge Park	11/3/2016	44.45	33.80	10.65
MW-B2020C	Eldredge Park	11/14/2016	44.45	33.98	10.47
MW-B2020C	Eldredge Park	1/18/2017	44.45	34.22	10.23
MW-B2020C	Eldredge Park	1/27/2017	44.45	34.07	10.38
MW-B2020C	Eldredge Park	2/24/2017	44.45	33.55	10.90
MW-B2020C	Eldredge Park	4/25/2017	44.45	32.90	11.55
MW-B2020C	Eldredge Park	6/29/2017	44.45	32.43	12.02
MW-B2020C	Eldredge Park	9/13/2017	44.45	32.23	12.22
MW-B2050A	Eldredge Park	11/3/2016	44.06	33.41	10.65
MW-B2050A	Eldredge Park	11/14/2016	44.06	33.60	10.46
MW-B2050A	Eldredge Park	1/18/2017	44.06	33.88	10.18
MW-B2050A	Eldredge Park	1/27/2017	44.06	33.64	10.42
MW-B2050A	Eldredge Park	2/24/2017	44.06	33.04	11.02
MW-B2050A	Eldredge Park	4/25/2017	44.06	32.68	11.38
MW-B2050A	Eldredge Park	6/29/2017	44.06	32.12	11.94
MW-B2050A	Eldredge Park	9/13/2017	44.06	31.98	12.08
MW-B2050B	Eldredge Park	11/3/2016	44.28	33.60	10.68
MW-B2050B	Eldredge Park	11/14/2016	44.28	33.73	10.55
MW-B2050B	Eldredge Park	1/18/2017	44.28	34.00	10.28
MW-B2050B	Eldredge Park	1/27/2017	44.28	33.84	10.44
MW-B2050B	Eldredge Park	2/24/2017	44.28	33.32	10.96
MW-B2050B	Eldredge Park	4/25/2017	44.28	32.63	11.65
MW-B2050B	Eldredge Park	6/29/2017	44.28	32.20	12.08
MW-B2050B	Eldredge Park	9/13/2017	44.28	32.01	12.27
MW-B2050C	Eldredge Park	11/3/2016	44.17	33.35	10.82
MW-B2050C	Eldredge Park	11/14/2016	44.17	33.51	10.66
MW-B2050C	Eldredge Park	1/18/2017	44.17	33.90	10.27
MW-B2050C	Eldredge Park	1/27/2017	44.17	33.87	10.30
MW-B2050C	Eldredge Park	2/24/2017	44.17	33.07	11.10
MW-B2050C	Eldredge Park	4/25/2017	44.17	32.31	11.86
MW-B2050C	Eldredge Park	6/29/2017	44.17	31.93	12.24
MW-B2050C	Eldredge Park	9/13/2017	44.17	32.07	12.10
MW-B2075A	Eldredge Park	4/25/2017	44.23	32.40	11.83
MW-B2075A	Eldredge Park	6/29/2017	44.23	31.97	12.26
MW-B2075A	Eldredge Park	9/12/2017	44.23	31.85	12.38
MW-B2100	Eldredge Park	11/3/2016	44.23	33.50	10.73
MW-B2100	Eldredge Park	11/14/2016	44.23	33.65	10.58
MW-B2100	Eldredge Park	1/18/2017	44.23	33.87	10.36
MW-B2100	Eldredge Park	1/27/2017	44.23	33.66	10.57
MW-B2100	Eldredge Park	2/24/2017	44.23	33.10	11.13
MW-B2100	Eldredge Park	4/25/2017	44.23	32.38	11.85
MW-B2100	Eldredge Park	6/29/2017	44.23	32.01	12.22
MW-B2100	Eldredge Park	9/12/2017	44.23	31.89	12.34
MW-BC1C	Eldredge Park	11/3/2016	42.50	31.36	11.14
MW-BC1C	Eldredge Park	11/14/2016	42.50	31.87	10.63
MW-BC1C	Eldredge Park	1/18/2017	42.50	31.81	10.69
MW-BC1C	Eldredge Park	1/27/2017	42.50	31.65	10.85
MW-BC1C	Eldredge Park	2/24/2017	42.50	31.14	11.36
MW-BC1C	Eldredge Park	4/25/2017	42.50	30.43	12.07
MW-BC1C	Eldredge Park	6/29/2017	42.50	30.07	12.43
MW-BC1C	Eldredge Park	9/12/2017	42.50	N/A	N/A

Table 2 Orleans Groundwater Elevations

Well ID	Location	Date	TOC Elevation (ft)	Depth to Water (ft)	GW Elevation (ft)
MW-BC2C[2]	Eldredge Park	6/29/2017	N/A	31.61	N/A
MW-BC2C[2]	Eldredge Park	11/3/2016	N/A	32.84	N/A
MW-BC2C[2]	Eldredge Park	11/14/2016	N/A	N/A	N/A
MW-BC2C[2]	Eldredge Park	1/18/2017	N/A	33.22	N/A
MW-BC2C[2]	Eldredge Park	1/27/2017	N/A	33.08	N/A
MW-BC2C[2]	Eldredge Park	2/24/2017	N/A	32.63	N/A
MW-BC2C[2]	Eldredge Park	4/25/2017	N/A	31.93	N/A
MW-BC2C[2]	Eldredge Park	9/13/2017	N/A	31.26	N/A
MW-BC3B	Eldredge Park	4/25/2017	43.86	32.45	11.41
MW-BC3B	Eldredge Park	6/29/2017	43.86	31.90	11.96
MW-BC3B	Eldredge Park	9/12/2017	43.86	31.50	12.36
MW-BU1A	Eldredge Park	11/3/2016	43.48	32.55	10.93
MW-BU1A	Eldredge Park	11/14/2016	43.48	32.44	11.04
MW-BU1A	Eldredge Park	1/18/2017	43.48	32.86	10.62
MW-BU1A	Eldredge Park	1/27/2017	43.48	32.74	10.74
MW-BU1A	Eldredge Park	2/24/2017	43.48	32.30	11.18
MW-BU1A	Eldredge Park	4/25/2017	43.48	31.75	11.73
MW-BU1A	Eldredge Park	6/29/2017	43.48	31.36	12.12
MW-BU1A	Eldredge Park	9/13/2017	43.48	31.21	12.27
MW-BU1C	Eldredge Park	11/3/2016	43.65	32.50	11.15
MW-BU1C	Eldredge Park	11/14/2016	43.65	N/A	N/A
MW-BU1C	Eldredge Park	1/18/2017	43.65	32.84	10.81
MW-BU1C	Eldredge Park	1/27/2017	43.65	32.72	10.93
MW-BU1C	Eldredge Park	2/24/2017	43.65	32.25	11.40
MW-BU1C	Eldredge Park	4/25/2017	43.65	31.71	11.94
MW-BU1C	Eldredge Park	6/29/2017	43.65	31.31	12.34
MW-BU1C	Eldredge Park	9/13/2017	43.65	31.03	12.62
MW-BU2A	Eldredge Park	11/3/2016	44.56	33.90	10.66
MW-BU2A	Eldredge Park	11/14/2016	44.56	34.03	10.53
MW-BU2A	Eldredge Park	1/18/2017	44.56	34.22	10.34
MW-BU2A	Eldredge Park	1/27/2017	44.56	34.05	10.51
MW-BU2A	Eldredge Park	2/23/2017	44.56	34.62	9.94
MW-BU2A	Eldredge Park	4/25/2017	44.56	33.25	11.31
MW-BU2A	Eldredge Park	6/29/2017	44.56	32.72	11.84
MW-BU2A	Eldredge Park	9/12/2017	44.56	32.56	12.00
MW-BU2B	Eldredge Park	11/3/2016	44.70	33.93	10.77
MW-BU2B	Eldredge Park	11/14/2016	44.70	34.07	10.63
MW-BU2B	Eldredge Park	1/18/2017	44.70	34.31	10.39
MW-BU2B	Eldredge Park	1/27/2017	44.70	34.15	10.55
MW-BU2B	Eldredge Park	2/23/2017	44.70	33.75	10.95
MW-BU2B	Eldredge Park	4/25/2017	44.70	33.10	11.60
MW-BU2B	Eldredge Park	6/29/2017	44.70	32.72	11.98
MW-BU2B	Eldredge Park	9/12/2017	44.70	32.47	12.23

Table 2 Orleans Groundwater Elevations

Well ID	Location	Date	TOC Elevation (ft)	Depth to Water (ft)	GW Elevation (ft)
MW-BU2C	Eldredge Park	11/3/2016	44.68	33.99	10.69
MW-BU2C	Eldredge Park	11/14/2016	44.68	34.08	10.60
MW-BU2C	Eldredge Park	1/18/2017	44.68	34.30	10.38
MW-BU2C	Eldredge Park	1/27/2017	44.68	34.15	10.53
MW-BU2C	Eldredge Park	2/23/2017	44.68	34.05	10.63
MW-BU2C	Eldredge Park	4/25/2017	44.68	33.08	11.60
MW-BU2C	Eldredge Park	6/29/2017	44.68	32.64	12.04
MW-BU2C	Eldredge Park	9/12/2017	44.68	32.60	12.08
MW-BX1B	Eldredge Park	4/25/2017	45.38	33.85	11.53
MW-BX1B	Eldredge Park	6/29/2017	45.38	33.46	11.92
MW-BX1B	Eldredge Park	9/12/2017	45.38	33.43	11.95
MW-BX1C	Eldredge Park	4/25/2017	45.37	33.29	12.08
MW-BX1C	Eldredge Park	6/29/2017	45.37	32.98	12.39
MW-BX1C	Eldredge Park	9/12/2017	45.37	32.98	12.39

Notes:

N/A = Not Available

1. MW-12C (Existing) was damaged during winter 2017. Water elevations taken since then may be affected, particulary September 2017 Result.

2. MW-BC2C has not yet been surveyed.

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-4**[3]	**MW-8**[3]	**MW-12A**					**MW-12B**				
Top of Screen Elevation (ft)	4.50	19.70	-24.4					-9.4				
Bottom of Screen Elevation (ft)	-5.50	9.70	-34.4					-19.4				
Sampling Date	10/4/2016	10/4/2016	11/03/2016[1]	1/5/2017	2/23/2017	6/28/2017	9/12/2017	11/03/2016[1]	1/5/2017	2/23/2017	6/28/2017	9/12/2017
Type of Sample	Sample	Sample	Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample	Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample
Field Measurements												
pH (SU)	5.52	5.23	6.94	5.46	5.53	5.58	5.59	6.90	5.43	5.40	5.39	5.45
Temperature (^{o}C)	15.54	15.87	14.38	11.78	13.81	13.91	14.02	14.50	11.82	14.18	14.37	14.56
Dissolved Oxygen (DO, mg/L)	7.89	9.58	1.13	3.69	7.03	14.81	6.92	1.05	1.16	6.39	12.40	5.51
Redox Potential (ORP; mV)	57.90	135.00	70.90	197.60	183.10	173.60	146.50	20.30	212.80	263.10	225.20	170.30
Specific Conductivity (µS/cm)[c]	171.00	190.00	667.00	572.00	550.00	537.00	518.00	231.00	243.00	235.00	253.00	257.00
Turbidity (NTU)	-	-	17.70	5.50	5.31	5.13	7.68	8.73	1.89	0.91	2.62	1.52
Laboratory Analyses												
Nitrogen												
Nitrate as N (mg/L)	**2.45**	**9.24**	**0.783**	**0.669**	**0.849**	**0.786**	**0.794**	**6.17**	**5.08**	**5.33**	**6.19**	**4.9**
Nitrite as N (mg/L)	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia (mg/L)	**0.1**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**0.19**	<0.1	**0.12**	**0.26**
Total Kjeldahl Nitrogen (TKN) (mg/L)	**0.71**	**1.7**	-	<0.2	**0.4**	-		-	**0.79**	**1.18**	-	
Total Nitrogen (mg/L)	**3.15**	**10.9**	**1**	**0.669**	**1.25**	**0.79**	**1.11**	**6.44**	**5.87**	**6.52**	**6.83**	**4.9**
Anions												
Chloride (mg/L)	**27.2**	**18.3**	**190**	**230**	**141**	**154**	**146**	**34.1**	**24.2**	**41.6**	**48.9**	**50.5**
Sulfate (mg/L)	**12.8**	**10.1**	**10**	**16.1**	**13.4**	**12.6**	**12.3**	**9.8**	**13.6**	**9.7**	**9.2**	**12.1**
Elements												
Dissolved Iron (mg/L)	-	-	**0.7**	-	<0.1	<0.1	**-**	**0.36**	-	<0.05	<0.1	**-**
Dissolved Manganese (mg/L)	-	-	**0.325**	-	**0.033**	<0.02	**-**	**0.228**	-	**0.046**	<0.02	**-**
Boron (mg/L)	-	-	<0.05	-	<0.05	-		<0.05	-	<0.05	-	
Sodium (mg/L)	-	-	-	-	**98.3**	-		-	-	**18.7**	-	
Other												
DOC (mg/L)	<0.5	<0.5	**0.55**	-	<0.5	**2.16**	**0.792**	**1.82**	-	<0.5	**1.02**	**1.1**
Methane (µg/L)	-	-	-	-	-	**-**		-	-	-	**-**	
Alkalinity as CaCO3 (mg/L)	-	-	-	**5**	**7**	-		-	**2**	**10**	-	

Notes:

NS - Not Sampled

Bold - detected above the Minimum Detection Limit

D -Duplicate

1. DO was measured in the field as DO(%) and was converted using the online tool at: http://www.hbuehrer.ch/Rechner/O2satur.html

2. MW-12C references "MW-12" that was installed as part of the Nauset Regional Middle School monitoring well network.

3. Existing wells (MW-4, MW-8, MW-12C) screen elevations were determined based on field measurement of depth to bottom of well. Actual screen depths may vary if bottom was affected by silt build-up in well.

4. MW-12C (existing) was damaged during snow removal at the site. A sample was unable to be taken during the Quarter 1 and 2 Sampling Events.

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-12C**[2,3]					**MA-BU1A**	**MW-BU1C**	**MW-BU2A**				
Top of Screen Elevation (ft)	8.60					-26.3	4	-24.9				
Bottom of Screen Elevation (ft)	-1.40					-36.3	-6	-34.9				
Sampling Date	10/4/2016	11/03/2016[1]	11/17/2016	1/5/2017	2/23/2017	10/4/2016	10/4/2016	11/03/2016[1]	1/5/2017	2/23/2017	6/29/2017	9/12/2017
Type of Sample	Sample	Sample	Sample	Sample	Q1 Sample[4]	Sample	Sample	Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample
Field Measurements												
pH (SU)	4.98	6.45	5.23	5.09	NS	5.44	5.27	6.73	6.00	5.72	5.68	5.72
Temperature (^{o}C)	17.50	14.08	14.42	12.60	NS	13.75	13.95	14.15	11.75	13.71	14.00	14.47
Dissolved Oxygen (DO, mg/L)	6.93	0.83	0.68	1.61	NS	7.60	8.75	1.18	1.30	6.82	15.26	6.87
Redox Potential (ORP; mV)	167.80	246.00	279.70	205.60	NS	70.90	130.90	37.50	127.00	149.50	225.20	172.00
Specific Conductivity (µS/cm)[c]	178.00	216.00	156.00	199.00	NS	1464.00	351.00	406.00	421.00	427.00	439.00	442.00
Turbidity (NTU)	-	0.60	2.58	0.84	NS	-	-	44.50	257.00	378.00	2.55	4.02
Laboratory Analyses												
Nitrogen												
Nitrate as N (mg/L)	**6.74**	**6.51**	-	**6.03**	NS	**0.443**	**1.97**	**0.357**	**0.426**	**0.452**	**0.408**	**0.61**
Nitrite as N (mg/L)	-	-	-	<0.01	NS	-	-	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia (mg/L)	<0.1	**0.11**	-	**0.12**	NS	**0.24**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Kjeldahl Nitrogen (TKN) (mg/L)	**1.34**	-	-	**1.24**	NS	**0.38**	**0.4**	-	<0.2	**0.3**	-	
Total Nitrogen (mg/L)	**8.08**	**6.51**	-	**7.27**	NS	**0.827**	**2.37**	**0.357**	**0.426**	**0.76**	**0.408**	**0.834**
Anions												
Chloride (mg/L)	**24.1**	-	-	**22.4**	NS	**458**	**96.1**	**103**	**118**	**117**	**120**	**123**
Sulfate (mg/L)	**8.7**	**9.3**	-	**8.6**	NS	**6.9**	**9.1**	**7.2**	**5.2**	**5.3**	<5	<5
Elements												
Dissolved Iron (mg/L)	-	<0.05	-	-	NS	**0.799**	**0.099**	**1.09**	-	**0.477**	<0.1	**-**
Dissolved Manganese (mg/L)	-	**0.02**	-	-	NS	**0.185**	**0.047**	**0.18**	-	**0.03**	<0.02	**-**
Boron (mg/L)	-	<0.05	-	-	NS	<0.05	<0.05	<0.05	-	<0.05	-	
Sodium (mg/L)	-	-	-	-	-	-	-	-	-	**63**	-	
Other												
DOC (mg/L)	<0.5	**0.87**	**0.674**	-	NS	<0.5	<0.5	<0.5	-	**0.53**	<0.5	**0.707**
Methane (µg/L)	-	-	-	-	NS	<2	<2	-	-	-	-	
Alkalinity as CaCO3 (mg/L)	-	-	**4**	**6**	NS	-	-	-	**11**	**10**	-	

Notes:

NS - Not Sampled

Bold - detected above the Minimum Detection Limit

D -Duplicate

1. DO was measured in the field as DO(%) and was converted using the online tool at: http://www.hbuehrer.ch/Rechner/O2satur.html

2. MW-12C references "MW-12" that was installed as part of the Nauset Regional Middle School monitoring well network.

3. Existing wells (MW-4, MW-8, MW-12C) screen elevations were determined based on field measurement of depth to bottom of well. Actual screen depths may vary if bottom was affected by silt build-up in well.

4. MW-12C (existing) was damaged during snow removal at the site. A sample was unable to be taken during the Quarter 1 and 2 Sampling Events.

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-BU2B**					**MW-BU2C**						**MW-BC1C**
Top of Screen Elevation (ft)	-9.9					5.10						2.5
Bottom of Screen Elevation (ft)	-19.9					-4.90						-7.5
Sampling Date	11/03/2016[1]	1/5/2017	2/23/2017	6/29/2017	9/12/2017	11/03/2016[1]	11/17/2016	1/10/2017	2/23/2017	6/29/2017	9/12/2017	10/4/2016
Type of Sample	Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample	Sample	Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample	Sample
Field Measurements												
pH (SU)	7.11	5.94	5.73	5.68	5.75	7.14	5.46	5.49	5.62	5.27	5.26	5.48
Temperature (^{o}C)	14.70	12.07	14.18	14.70	15.21	15.20	14.89	12.78	14.78	15.22	15.67	13.37
Dissolved Oxygen (DO, mg/L)	1.30	1.07	6.25	13.80	6.19	1.31	2.17	2.40	5.96	11.94	5.59	7.75
Redox Potential (ORP; mV)	20.20	136.30	177.60	221.40	156.50	203.00	51.20	194.10	227.50	249.50	208.60	70.10
Specific Conductivity (µS/cm)[c]	379.00	362.00	343.00	336.00	350.00	535.00	516.00	569.00	367.00	579.00	658.00	1029.00
Turbidity (NTU)	102.00	146.00	32.60	4.16	8.58	11.40	14.20	5.55	7.33	2.08	11.35	-
Laboratory Analyses												
Nitrogen												
Nitrate as N (mg/L)	**1.06**	**0.826**	**1.01**	**0.768**	**1.07**	**5.39**	-	**7.42**	**1.78**	**5.39**	**6.35**	**0.481**
Nitrite as N (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	-
Ammonia (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	**0.1**	<0.1	<0.1	<0.1	-
Total Kjeldahl Nitrogen (TKN) (mg/L)	-	<0.2	**0.43**	-		-	-	<0.2	**0.55**	-		-
Total Nitrogen (mg/L)	**1.06**	**0.826**	**1.44**	**0.768**	**1.07**	**5.39**	-	-	**2.32**	**5.39**	**6.35**	**0.481**
Anions												
Chloride (mg/L)	**97.3**	**92.2**	**90.7**	**88.3**	**93.2**	**134**	-	**143**	**96.8**	**146**	**174**	**438**
Sulfate (mg/L)	<5	<5	<5	<5	<5	<5	-	<5	<5	<5	<5	**11.5**
Elements												
Dissolved Iron (mg/L)	**0.667**	-	**0.138**	<0.1	**-**	**0.817**	-	-	<0.1	<0.1	**-**	-
Dissolved Manganese (mg/L)	**0.088**	-	<0.02	<0.02	**-**	**0.26**	-	-	**0.077**	**0.081**	**-**	-
Boron (mg/L)	<0.05	-	<0.05	-		<0.05	-	-	<0.05	-		-
Sodium (mg/L)	-	-	**37.2**	-		-	-	-	**44.9**	-		-
Other												
DOC (mg/L)	**0.612**	-	<0.5	**0.579**	**0.856**	**0.684**	**0.728**	<0.5	<0.5	**0.599**	**1.35**	<0.5
Methane (µg/L)	<2	-	-	-		<2	-	-	-	-		-
Alkalinity as CaCO3 (mg/L)	-	**18**	**16**	-		-	**13**	**11**	**17**	-		-

Notes:

NS - Not Sampled

Bold - detected above the Minimum Detection Limit

D -Duplicate

1. DO was measured in the field as DO(%) and was converted using the online tool at: http://www.hbuehrer.ch/Rechner/O2satur.html

2. MW-12C references "MW-12" that was installed as part of the Nauset Regional Middle School monitoring well network.

3. Existing wells (MW-4, MW-8, MW-12C) screen elevations were determined based on field measurement of depth to bottom of well. Actual screen depths may vary if bottom was affected by silt build-up in well.

4. MW-12C (existing) was damaged during snow removal at the site. A sample was unable to be taken during the Quarter 1 and 2 Sampling Events.

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-BC2C**						**MW-BC3**			**MW-BX1B**			
Top of Screen Elevation (ft)	N/A						-10.80			-9.40			
Bottom of Screen Elevation (ft)	N/A						-20.80			-19.40			
Sampling Date	11/04/2016	11/17/2016	1/10/2017	2/24/2017	6/29/2017	9/13/2017	3/27/2017	6/29/2017	9/13/2017	3/27/2017	6/28/2017	9/12/2017	3/27/2017
Type of Sample	Sample	Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample	Sample	Q2 Sample	Q3 Sample	Sample	Q2 Sample	Q3 Sample	Sample
Field Measurements													
pH (SU)	7.05	5.40	5.55	5.17	5.28	5.30	5.38	5.31	5.41	4.67	5.05	5.03	4.44
Temperature (^{o}C)	15.25	14.54	12.65	15.10	15.07	15.49	14.19	14.13	14.24	13.76	14.28	14.50	13.87
Dissolved Oxygen (DO, mg/L)	1.65	1.67	1.87	5.73	12.16	4.94	2.50	6.98	3.29	1.73	1.87	0.07	0.63
Redox Potential (ORP; mV)	74.80	100.70	169.00	259.10	239.90	256.70	113.80	251.90	238.30	153.70	283.60	202.90	199.90
Specific Conductivity (µS/cm)[c]	368.00	340.00	363.00	332.00	361.00	416.00	518.00	611.00	630.00	367.00	446.00	470.00	521.00
Turbidity (NTU)	6.00	19.20	16.60	20.40	3.76	2.62	5.69	16.40	5.82	29.80	326.00	19.44	0.98
Laboratory Analyses													
Nitrogen													
Nitrate as N (mg/L)	**4.16**	-	**5.91**	**3.32**	**3.42**	**3.13**	**2.2**	**4.59**	**3.45**	**11.4**	**34.4**	**39**	**0.25**
Nitrite as N (mg/L)	-	-	<0.01	<0.01	<0.01	<0.01	**0.032**	<0.01	<0.01	**0.018**	<0.01	<0.01	**0.012**
Ammonia (mg/L)	<0.1	-	<0.1	<0.1	<0.1	**0.12**	**0.91**	<0.1	<0.1	**0.4**	**0.7**	**0.39**	**1.09**
Total Kjeldahl Nitrogen (TKN) (mg/L)	-	-	<0.2	**0.92**	-	**-**	-	-	-	-	-		-
Total Nitrogen (mg/L)	**4.43**	-		**4.24**	**3.42**	**3.13**	**2.59**	**4.59**	**3.45**	**12.9**	**37**	**39**	**1.52**
Anions													
Chloride (mg/L)	**83.8**	-	**85.4**	**83.3**	**86.5**	**92.5**	**143**	**161**	**153**	**43.1**	**41**	**37.9**	**49.6**
Sulfate (mg/L)	**6.4**	-	<5	**6.3**	<5	<5	**8.3**	**6.8**	**9.1**	**7.6**	<5	<5	<5
Elements													
Dissolved Iron (mg/L)	-	-	-	<0.1	<0.1	**-**	<0.1	<0.1	**-**	<0.1	<0.1	**-**	<0.1
Dissolved Manganese (mg/L)	-	-	-	**0.092**	**0.062**	**-**	**0.298**	**0.077**	**-**	**0.335**	**0.478**	**-**	**0.566**
Boron (mg/L)	-	-	-	<0.05	-	**-**	-	-	-	-	-		-
Sodium (mg/L)	-	-	-	41.8	-	**-**	-	-	-	-	-		-
Other													
DOC (mg/L)	**0.764**	**0.576**	<0.5	**1.54**	**1.68**	**3.32**	**1.86**	**1.02**	**3.79**	**2.97**	**1.55**	**2.31**	**2.7**
Methane (µg/L)	-	-	-	-	-	**-**	-	-	-	-	**-**		-
Alkalinity as CaCO3 (mg/L)	-	**8**	**9**	**9**	-	**-**	-	-	-	-	-		-

Notes:

NS - Not Sampled

Bold - detected above the Minimum Detection Limit

D -Duplicate

1. DO was measured in the field as DO(%) and was converted using the online tool at: http://www.hbuehrer.ch/Rechner/O2satur.html

2. MW-12C references "MW-12" that was installed as part of the Nauset Regional Middle School monitoring well network.

3. Existing wells (MW-4, MW-8, MW-12C) screen elevations were determined based on field measurement of depth to bottom of well. Actual screen depths may vary if bottom was affected by silt build-up in well.

4. MW-12C (existing) was damaged during snow removal at the site. A sample was unable to be taken during the Quarter 1 and 2 Sampling Events.

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-BX1C**		**MW-B1010C**					
Top of Screen Elevation (ft)	5.70		-0.10					
Bottom of Screen Elevation (ft)	-4.30		-10.10					
Sampling Date	6/28/2017	9/12/2017	11/03/2016[1]	11/17/2016	1/5/2017	2/23/2017	6/28/2017	9/12/2017
Type of Sample	Q2 Sample	Q3 Sample	Sample	Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample
Field Measurements								
pH (SU)	4.70	4.80	6.90	5.18	5.61	5.32	5.36	5.68
Temperature (^{o}C)	14.32	14.44	14.60	14.28	12.22	14.69	15.04	15.97
Dissolved Oxygen (DO, mg/L)	2.30	0.79	0.87	0.71	0.49	1.07	1.39	0.12
Redox Potential (ORP; mV)	315.80	232.40	110.70	231.60	190.80	252.20	204.80	2.70
Specific Conductivity (µS/cm)[c]	473.00	447.00	262.00	230.00	289.00	258.00	269.00	238.00
Turbidity (NTU)	55.80	7.11	16.00	5.97	10.60	5.62	2.73	2.99
Laboratory Analyses								
Nitrogen								
Nitrate as N (mg/L)	**38.7**	**37.8**	**13.6**	-	**6.74**	**9.94**	**13.8**	**2.49**
Nitrite as N (mg/L)	<0.01	<0.01	-	-	**0.509**	**0.474**	**0.171**	**0.185**
Ammonia (mg/L)	**0.5**	**0.22**	<0.1	-	<0.1	**0.18**	<0.1	<0.1
Total Kjeldahl Nitrogen (TKN) (mg/L)	-		-	-	**1.36**	**1.95**	-	
Total Nitrogen (mg/L)	**42**	**37.8**	**13.9**	-	**8.61**	**12.4**	**15.7**	**4.22**
Anions								
Chloride (mg/L)	**40.8**	**37.3**	**27.5**	-	**24.3**	**25.2**	**24.2**	**23.6**
Sulfate (mg/L)	<5	<5	-	-	**23.7**	**16.5**	**11**	**22.6**
Elements								
Dissolved Iron (mg/L)	<0.1	**-**	-	-	-	<0.1	**0.143**	**3.88**
Dissolved Manganese (mg/L)	**0.517**	**-**	-	-	-	**0.234**	**0.324**	**0.996**
Boron (mg/L)	-		-	-	-	<0.05	-	
Sodium (mg/L)	-		-	-	-	**22.8**	-	
Other								
DOC (mg/L)	**2.02**	**2.69**	-	**0.696**	-	**13.9**	**16.9**	**21.4**
Methane (µg/L)	**-**		-	-	-	-	<2	
Alkalinity as CaCO3 (mg/L)	-		-	**11**	**31**	**15**	-	

Notes:

NS - Not Sampled

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D -Duplicate

1. DO was measured in the field as DO(%) and was converted using the online tool at: http://www.hbuehrer.ch/Rechner/O2satur.html

2. MW-12C references "MW-12" that was installed as part of the Nauset Regional Middle School monitoring well network.

3. Existing wells (MW-4, MW-8, MW-12C) screen elevations were determined based on field measurement of depth to bottom of well. Actual screen depths may vary if bottom was affected by silt build-up in well.

4. MW-12C (existing) was damaged during snow removal at the site. A sample was unable to be taken during the Quarter 1 and 2 Sampling Events.

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-B1020B**					**MW-B1020C**					
Top of Screen Elevation (ft)	-10.4					4.50					
Bottom of Screen Elevation (ft)	-20.4					-5.50					
Sampling Date	11/04/2016[1]	1/5/2017	2/23/2017	6/28/2017	9/12/2017	11/04/2016[1]	11/17/2016	1/5/2017	2/23/2017	6/28/2017	9/12/2017
Type of Sample	Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample	Sample	Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample
Field Measurements											
pH (SU)	6.78	5.20	5.01	5.00	5.12	6.88	5.27	5.38	5.17	5.16	5.22
Temperature (^{o}C)	13.70	11.94	14.13	14.71	15.69	14.24	14.66	12.73	15.06	15.26	15.97
Dissolved Oxygen (DO, mg/L)	1.03	0.60	2.77	1.44	0.20	1.44	0.56	0.31	2.69	3.72	1.81
Redox Potential (ORP; mV)	45.00	190.70	251.30	276.30	160.30	50.30	106.70	194.80	292.20	277.20	161.90
Specific Conductivity (µS/cm)[c]	465.00	355.00	353.00	352.00	332.00	242.00	227.00	269.00	253.00	247.00	161.90
Turbidity (NTU)	67.90	321.00	11.00	14.60	2.50	321.00	15.60	6.31	18.00	8.87	243.00
Laboratory Analyses											
Nitrogen											
Nitrate as N (mg/L)	**28.4**	**17.9**	**20.1**	**24.9**	**19.7**	**10.6**	-	**11.1**	**12.6**	**13.9**	**12.4**
Nitrite as N (mg/L)	-	<0.01	<0.01	**0.158**	**0.076**	-	-	<0.01	<0.01	<0.01	<0.01
Ammonia (mg/L)	**0.53**	**0.11**	<0.1	<0.1	<0.1	<0.1	-	**0.19**	<0.1	<0.1	<0.1
Total Kjeldahl Nitrogen (TKN) (mg/L)	-	**1.79**	**2.92**	-		-	-	**1.99**	**2.25**	-	
Total Nitrogen (mg/L)	**28.5**	**19.6**	**23**	**27.1**	**19.7**	**10.6**	-	**13.1**	**14.9**	**15**	**12.4**
Anions											
Chloride (mg/L)	**49.8**	**33.6**	**34**	**32.3**	**30**	**25.5**	-	**25.6**	**25.6**	**24.8**	**24.1**
Sulfate (mg/L)	-	<5	<5	<5	<5	-	-	**5.6**	**6.1**	**5.8**	**5.8**
Elements											
Dissolved Iron (mg/L)	**2.52**	-	**0.153**	<0.1	<0.1	**2.23**	-	-	<0.1	<0.1	<0.1
Dissolved Manganese (mg/L)	**0.948**	-	**0.293**	**0.333**	**0.32**	**0.249**	-	-	**0.076**	**0.057**	**0.042**
Boron (mg/L)	<0.05	-	**0.053**	-		**0.085**	-	-	**0.083**	-	
Sodium (mg/L)	**27.5**	-	**24.6**	-		**13.4**	-	-	**18.4**	-	
Other											
DOC (mg/L)	-	-	**1.11**	**3.24**	**3.67**	-	**0.85**	-	**1.02**	**1.34**	**2.19**
Methane (µg/L)	-	-	-	**-**		-	-	-	-	**-**	
Alkalinity as CaCO3 (mg/L)	-	**9**	**6**	-		-	**13**	**11**	**8**	-	

Notes:

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D -Duplicate

1. DO was measured in the field as DO(%) and was converted using the online tool at: http://www.hbuehrer.ch/Rechner/O2satur.html

2. MW-12C references "MW-12" that was installed as part of the Nauset Regional Middle School monitoring well network.

3. Existing wells (MW-4, MW-8, MW-12C) screen elevations were determined based on field measurement of depth to bottom of well. Actual screen depths may vary if bottom was affected by silt build-up in well.

4. MW-12C (existing) was damaged during snow removal at the site. A sample was unable to be taken during the Quarter 1 and 2 Sampling Events.

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-B1050A**					**MW-B1050B**			
Top of Screen Elevation (ft)	-26.1					-11.1			
Bottom of Screen Elevation (ft)	-36.1					-21.1			
Sampling Date	11/04/2016[1]	1/5/2017	2/23/2017	6/28/2017	9/12/2017	11/04/2016[1]	2/23/2017	6/28/2017	9/12/2017
Type of Sample	Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample
Field Measurements									
pH (SU)	7.15	5.60	5.50	5.00	5.27	7.06	5.13	5.10	5.22
Temperature (^{o}C)	13.77	11.87	14.05	14.27	15.87	14.08	14.27	14.70	15.48
Dissolved Oxygen (DO, mg/L)	1.34	0.26	4.24	1.75	0.06	1.17	2.12	4.53	1.06
Redox Potential (ORP; mV)	43.00	142.20	226.20	264.40	174.20	80.30	304.40	260.10	203.80
Specific Conductivity (µS/cm)[c]	612.00	505.00	1648.00	508.00	422.00	446.00	463.00	387.00	340.00
Turbidity (NTU)	962.00	297.00	76.60	4.10	3.10	3.97	7.20	0.72	2.75
Laboratory Analyses									
Nitrogen									
Nitrate as N (mg/L)	**37**	**26.6**	**11.8**	**26.8**	**26.7**	**25.7**	**28.7**	**18.2**	**18**
Nitrite as N (mg/L)	-	**0.105**	<0.01	**0.038**	**0.048**	-	<0.01	<0.01	<0.01
Ammonia (mg/L)	**1.93**	**1.72**	**0.54**	**0.57**	**1.24**	**0.19**	<0.1	<0.1	**0.14**
Total Kjeldahl Nitrogen (TKN) (mg/L)	-	**3.75**	**1.83**	-		-	**1.85**	-	
Total Nitrogen (mg/L)	**37.2**	**30.5**	**13.7**	**26.8**	**26.7**	**26**	**30.5**	**18.2**	**18**
Anions									
Chloride (mg/L)	**54.8**	**48.9**	**399**	**48.9**	**41.4**	**48.2**	**50.7**	**41.7**	**38.2**
Sulfate (mg/L)	-	**6.1**	<5	<5	<5	-	<5	<5	<5
Elements									
Dissolved Iron (mg/L)	**4.29**	-	<0.1	<0.1	**-**	**0.734**	<0.1	<0.1	**-**
Dissolved Manganese (mg/L)	**0.655**	-	**0.18**	**0.654**	**-**	**0.332**	**0.142**	**0.101**	**-**
Boron (mg/L)	<0.05	-	<0.05	-		<0.05	<0.05	-	
Sodium (mg/L)	**33.7**	-	**345**	-		**26.8**	**16.9**	-	
Other									
DOC (mg/L)	-	-	**0.808**	**1.85**	**3.72**	-	**0.722**	**1.31**	**3.43**
Methane (µg/L)	-	-	-	-		-	-	-	
Alkalinity as CaCO3 (mg/L)	-	**24**	**11**	-		-	**7**	-	

Notes:

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D -Duplicate

1. DO was measured in the field as DO(%) and was converted using the online tool at: http://www.hbuehrer.ch/Rechner/O2satur.html

2. MW-12C references "MW-12" that was installed as part of the Nauset Regional Middle School monitoring well network.

3. Existing wells (MW-4, MW-8, MW-12C) screen elevations were determined based on field measurement of depth to bottom of well. Actual screen depths may vary if bottom was affected by silt build-up in well.

4. MW-12C (existing) was damaged during snow removal at the site. A sample was unable to be taken during the Quarter 1 and 2 Sampling Events.

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-B1050C**				**MW-B1075B**			
Top of Screen Elevation (ft)	4.9				-11.5			
Bottom of Screen Elevation (ft)	-5.1				-21.5			
Sampling Date	11/04/2016[1]	2/23/2017	6/28/2017	9/12/2017	11/04/2016[1]	2/23/2017	6/28/2017	9/13/2017
Type of Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample
Field Measurements								
pH (SU)	7.20	5.43	5.34	5.38	7.19	5.59	5.66	5.83
Temperature (^{o}C)	14.55	14.95	15.06	15.77	15.20	14.20	14.74	14.93
Dissolved Oxygen (DO, mg/L)	1.34	1.83	5.39	1.85	0.71	1.50	1.95	0.12
Redox Potential (ORP; mV)	48.60	205.90	230.20	176.50	82.20	157.90	223.10	99.00
Specific Conductivity (µS/cm)[c]	571.00	511.00	542.00	478.00	631.00	1755.00	736.00	719.00
Turbidity (NTU)	8.21	2.27	0.98	3.23	13.00	126.00	1.87	24.23
Laboratory Analyses								
Nitrogen								
Nitrate as N (mg/L)	**3.83**	**3.96**	**3.26**	**4.18**	**1.93**	**1**	**0.553**	**0.751**
Nitrite as N (mg/L)	-	<0.01	<0.01	<0.01	-	**0.048**	**0.05**	**0.064**
Ammonia (mg/L)	<0.1	<0.1	<0.1	<0.1	**3.73**	**5.26**	**11**	**12.2**
Total Kjeldahl Nitrogen (TKN) (mg/L)	-	1.28	-		-	**7.2**	-	**-**
Total Nitrogen (mg/L)	**4.05**	**5.24**	**3.26**	**4.4**	**6.36**	**8.25**	**13.6**	**15.1**
Anions								
Chloride (mg/L)	**141**	**123**	**134**	**120**	**96.3**	**440**	**170**	**147**
Sulfate (mg/L)	-	**20.1**	**15.2**	**14.6**	-	**25.6**	**28.9**	**26.8**
Elements								
Dissolved Iron (mg/L)	**0.493**	<0.1	<0.1	**-**	-	**0.342**	<0.1	**-**
Dissolved Manganese (mg/L)	**0.146**	**0.042**	**0.057**	**-**	-	**0.119**	**0.111**	**-**
Boron (mg/L)	<0.05	<0.05	-		-	<0.05	-	**-**
Sodium (mg/L)	**81.6**	**94.5**	-		-	**379**	-	**-**
Other								
DOC (mg/L)	-	**0.592**	**1.62**	**2.19**	-	**1.96**	**4.86**	**9.48**
Methane (µg/L)	-	-	-		-	-	-	**-**
Alkalinity as CaCO3 (mg/L)	-	**17**	-		-	**46**	-	**-**

Notes:

NS - Not Sampled

Bold - detected above the Minimum Detection Limit

D -Duplicate

1. DO was measured in the field as DO(%) and was converted using the online tool at: http://www.hbuehrer.ch/Rechner/O2satur.html

2. MW-12C references "MW-12" that was installed as part of the Nauset Regional Middle School monitoring well network.

3. Existing wells (MW-4, MW-8, MW-12C) screen elevations were determined based on field measurement of depth to bottom of well. Actual screen depths may vary if bottom was affected by silt build-up in well.

4. MW-12C (existing) was damaged during snow removal at the site. A sample was unable to be taken during the Quarter 1 and 2 Sampling Events.

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-B2010C**					**MW-B2020B**					
Top of Screen Elevation (ft)	0					-10.1					
Bottom of Screen Elevation (ft)	-10					-20.1					
Sampling Date	11/03/2016[1]	11/17/2016	2/24/2017	6/28/2017	9/13/2017	11/03/2016[1]	11/17/2016	1/10/2017	2/24/2017	6/28/2017	9/13/2017
Type of Sample	Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample	Sample	Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample
Field Measurements											
pH (SU)	7.04	5.32	5.70	6.11	6.29	7.00	5.22	5.05	5.10	5.04	5.45
Temperature (^{o}C)	15.12	14.58	14.81	15.39	15.69	14.91	14.39	12.23	14.53	14.86	15.14
Dissolved Oxygen (DO, mg/L)	0.67	0.61	3.38	1.78	0.10	1.15	0.63	0.85	2.03	3.88	0.08
Redox Potential (ORP; mV)	12.40	213.80	103.30	-41.60	-119.80	90.80	182.60	170.50	308.10	285.90	120.70
Specific Conductivity (µS/cm)[c]	333.00	304.00	302.00	431.00	689.00	321.00	307.00	344.00	338.00	354.00	323.00
Turbidity (NTU)	149.00	44.40	19.90	6.89	5.10	14.30	17.40	6.95	6.11	8.12	5.91
Laboratory Analyses											
Nitrogen											
Nitrate as N (mg/L)	**15.7**	-	**5.06**	**5.74**	**0.182**	**16.9**	-	**25.6**	**14.8**	**22.4**	**5.96**
Nitrite as N (mg/L)	-	-	**0.499**	**0.128**	**0.081**	**0.022**	-	<0.01	<0.01	<0.01	**0.54**
Ammonia (mg/L)	**0.14**	-	<0.1	**0.24**	<0.1	**0.1**	-	<0.1	<0.1	<0.1	<0.1
Total Kjeldahl Nitrogen (TKN) (mg/L)	-	-	**14.7**	-	-	-	-	<0.2	**3.86**	-	-
Total Nitrogen (mg/L)	**16.1**	-	**20.3**	**7.69**	**2.26**	**17.2**	-	-	**18.7**	**24.2**	**7.84**
Anions											
Chloride (mg/L)	**38.6**	-	**27.5**	**30**	**37.4**	**32.5**	-	**34.9**	**32.7**	**39.3**	**38**
Sulfate (mg/L)	**11**	-	**24.3**	**39.8**	**73.5**	**7.7**	-	**6**	**7.1**	**6.4**	**29.7**
Elements											
Dissolved Iron (mg/L)	-	-	**1.84**	**24.2**	**46.2**	**1.2**	-	-	<0.1	<0.1	<0.1
Dissolved Manganese (mg/L)	-	-	**0.189**	**1.62**	**2.56**	**0.126**	-	-	**0.028**	**0.029**	**0.187**
Boron (mg/L)	-	-	<0.05	-	-	<0.05	-	-	**0.054**	-	-
Sodium (mg/L)	-	-	**28.5**	-	-	-	-	-	**21.6**	-	-
Other											
DOC (mg/L)	**2.18**	**0.852**	**19.4**	**83.3**	**69.4**	**1.45**	**0.694**	<0.5	**1.02**	**3.47**	**29.8**
Methane (µg/L)	-	-	-	**11.3**	-	<2	-	-	-	**-**	-
Alkalinity as CaCO3 (mg/L)	-	**16**	**48**	-	-	-	**20**	**12**	**8**	-	-

Notes:

NS - Not Sampled

Bold - detected above the Minimum Detection Limit

D -Duplicate

1. DO was measured in the field as DO(%) and was converted using the online tool at: http://www.hbuehrer.ch/Rechner/O2satur.html

2. MW-12C references "MW-12" that was installed as part of the Nauset Regional Middle School monitoring well network.

3. Existing wells (MW-4, MW-8, MW-12C) screen elevations were determined based on field measurement of depth to bottom of well. Actual screen depths may vary if bottom was affected by silt build-up in well.

4. MW-12C (existing) was damaged during snow removal at the site. A sample was unable to be taken during the Quarter 1 and 2 Sampling Events.

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-B2020C**					**MW-B2050A**				
Top of Screen Elevation (ft)	4.8					-25.4				
Bottom of Screen Elevation (ft)	-5.2					-35.4				
Sampling Date	11/03/2016[1]	1/10/2017	2/24/2017	6/28/2017	9/13/2017	11/03/2016[1]	1/10/2017	2/24/2017	6/28/2017	9/13/2017
Type of Sample	Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample	Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample
Field Measurements										
pH (SU)	7.00	5.12	5.09	5.60	5.76	7.11	5.39	5.29	5.27	5.34
Temperature (^{o}C)	15.20	12.90	15.42	15.57	15.80	14.44	11.96	14.06	14.47	14.58
Dissolved Oxygen (DO, mg/L)	1.31	1.30	3.96	1.70	0.13	0.60	0.09	0.83	1.66	0.06
Redox Potential (ORP; mV)	29.80	201.50	316.20	73.80	-15.70	0.80	182.80	251.80	217.00	98.90
Specific Conductivity (µS/cm)[c]	249.00	251.00	225.00	264.00	248.00	540.00	520.00	550.00	505.00	509.00
Turbidity (NTU)	28.00	5.81	5.17	6.23	1.30	50.70	8.10	14.10	26.70	5.04
Laboratory Analyses										
Nitrogen										
Nitrate as N (mg/L)	**8.71**	**12.6**	**6.95**	**0.457**	<0.03	**35**	**39.3**	**27**	**32.8**	**25.5**
Nitrite as N (mg/L)	**0.016**	<0.01	<0.01	**0.072**	**0.01**	-	**0.025**	<0.010	<0.01	**0.166**
Ammonia (mg/L)	**0.24**	<0.1	<0.1	<0.1	<0.1	**1.05**	**0.87**	**0.89**	**1**	**0.63**
Total Kjeldahl Nitrogen (TKN) (mg/L)	-	<0.2	**2.33**	-	-	-	**3.32**	**3.5**	-	**-**
Total Nitrogen (mg/L)	**9.02**	-	**9.28**	**0.85**	**0.424**	**35.3**	-	**30.5**	**35.4**	**25.6**
Anions										
Chloride (mg/L)	**26.8**	**31**	**28.4**	**32.2**	**31.2**	**49.9**	**64.5**	**63.3**	**66.8**	**65.8**
Sulfate (mg/L)	**11.6**	**9.7**	**11.9**	**36.8**	**20.9**	**5.6**	**5.6**	**6.2**	**7.5**	**5.3**
Elements										
Dissolved Iron (mg/L)	**1.42**	-	<0.1	**7.97**	**13.1**	**3.2**	-	<0.1	<0.1	**-**
Dissolved Manganese (mg/L)	**1.14**	-	**0.067**	**0.964**	**2.08**	**0.407**	-	**0.293**	**0.26**	**-**
Boron (mg/L)	<0.05	-	<0.05	-	-	<0.05	-	<0.05	-	**-**
Sodium (mg/L)	-	-	**15.2**	-	-	-	-	**40**	-	**-**
Other										
DOC (mg/L)	**1.17**	<0.5	**2.04**	**23.3**	**14.2**	**1.61**	-	**1.08**	**1.37**	**5.63**
Methane (µg/L)	<2	-	-	**-**	-	-	-	-	**-**	**-**
Alkalinity as CaCO3 (mg/L)	-	**10**	**7**	-	-	-	**17**	**13**	-	**-**

Notes:

NS - Not Sampled

Bold - detected above the Minimum Detection Limit

D -Duplicate

1. DO was measured in the field as DO(%) and was converted using the online tool at: http://www.hbuehrer.ch/Rechner/O2satur.html

2. MW-12C references "MW-12" that was installed as part of the Nauset Regional Middle School monitoring well network.

3. Existing wells (MW-4, MW-8, MW-12C) screen elevations were determined based on field measurement of depth to bottom of well. Actual screen depths may vary if bottom was affected by silt build-up in well.

4. MW-12C (existing) was damaged during snow removal at the site. A sample was unable to be taken during the Quarter 1 and 2 Sampling Events.

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-B2050B**				**MW-B2050C**			
Top of Screen Elevation (ft)	-10.4				4.6			
Bottom of Screen Elevation (ft)	-20.4				-5.4			
Sampling Date	11/03/2016[1]	2/24/2017	6/28/2017	9/13/2017	11/03/2016[1]	2/24/2017	6/28/2017	9/13/2017
Type of Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample
Field Measurements								
pH (SU)	7.06	5.22	5.29	5.30	7.22	5.49	5.38	5.40
Temperature (^{o}C)	14.95	14.64	15.27	15.31	16.72	16.56	16.90	17.37
Dissolved Oxygen (DO, mg/L)	1.29	3.75	5.97	1.27	1.09	5.76	8.95	4.51
Redox Potential (ORP; mV)	80.50	304.60	242.20	169.70	82.50	179.50	236.30	177.90
Specific Conductivity (µS/cm)[c]	512.00	645.00	502.00	510.00	658.00	932.00	896.00	970.00
Turbidity (NTU)	123.00	4.67	5.78	0.61	212.00	36.10	9.68	20.03
Laboratory Analyses								
Nitrogen								
Nitrate as N (mg/L)	**4.75**	**3.64**	**5.27**	**3.94**	**3.01**	**1.68**	**3.05**	**2.19**
Nitrite as N (mg/L)	-	<0.010	<0.01	<0.01	-	<0.010	<0.01	<0.01
Ammonia (mg/L)	<0.1	<0.1	<0.1	<0.1	**0.11**	<0.1	**0.12**	<0.1
Total Kjeldahl Nitrogen (TKN) (mg/L)	-	**1.22**	-	-	-	**0.66**	-	-
Total Nitrogen (mg/L)	**5.15**	**4.86**	**5.91**	**3.94**	**3.3**	**2.34**	**3.75**	**2.53**
Anions								
Chloride (mg/L)	**123**	**173**	**124**	**119**	-	**251**	**253**	**278**
Sulfate (mg/L)	**11.5**	**11.5**	**11**	**8.7**	**11.9**	**11.1**	**10.1**	**8.9**
Elements								
Dissolved Iron (mg/L)	**0.551**	<0.1	<0.1	**-**	-	**0.308**	<0.1	**-**
Dissolved Manganese (mg/L)	**0.258**	**0.297**	**0.258**	**-**	-	**0.254**	**0.13**	**-**
Boron (mg/L)	<0.05	<0.05	-	-	-	<0.05	-	-
Sodium (mg/L)	-	**81.7**	-	-	-	**120**	-	-
Other								
DOC (mg/L)	**1.15**	**1.08**	**0.754**	**5.01**	**1.13**	**0.87**	**0.639**	**3.73**
Methane (µg/L)	-	-	**-**	-	-	-	**-**	-
Alkalinity as CaCO3 (mg/L)	-	**11**	-	-	-	**9**	-	-

Notes:

NS - Not Sampled

Bold - detected above the Minimum Detection Limit

D -Duplicate

1. DO was measured in the field as DO(%) and was converted using the online tool at: http://www.hbuehrer.ch/Rechner/O2satur.html

2. MW-12C references "MW-12" that was installed as part of the Nauset Regional Middle School monitoring well network.

3. Existing wells (MW-4, MW-8, MW-12C) screen elevations were determined based on field measurement of depth to bottom of well. Actual screen depths may vary if bottom was affected by silt build-up in well.

4. MW-12C (existing) was damaged during snow removal at the site. A sample was unable to be taken during the Quarter 1 and 2 Sampling Events.

Table 3 Orleans Monitoring Well Groundwater Data Summary

Sample ID	**MW-B2075A**			**MW-B2100**				
Top of Screen Elevation (ft)	-20.40			9.6				
Bottom of Screen Elevation (ft)	-30.40			-0.4				
Sampling Date	3/27/2017	6/28/2017	9/12/2017	10/4/2016	11/03/2016[1]	2/24/2017	6/28/2017	9/12/2017
Type of Sample	Sample	Q2 Sample	Q3 Sample	Sample	Sample	Q1 Sample	Q2 Sample	Q3 Sample
Field Measurements								
pH (SU)	5.21	5.50	5.53	5.26	6.98	5.46	5.27	5.41
Temperature (^{o}C)	14.42	14.98	15.40	14.42	14.95	16.84	14.44	14.43
Dissolved Oxygen (DO, mg/L)	4.08	7.83	7.02	5.90	1.50	7.37	10.84	5.09
Redox Potential (ORP; mV)	130.70	234.90	205.30	110.50	124.70	189.80	217.40	216.7
Specific Conductivity (µS/cm)[c]	744.00	748.00	883.00	272.00	297.00	346.00	364.00	377
Turbidity (NTU)	159.00	3.85	43.20	-	8.44	OVER	5.71	2.97
Laboratory Analyses								
Nitrogen								
Nitrate as N (mg/L)	**0.348**	**0.539**	**0.676**	**1.29**	**1.29**	**0.959**	**0.724**	**0.903**
Nitrite as N (mg/L)	<0.01	<0.01	<0.01	-	-	<0.010	<0.01	<0.01
Ammonia (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**0.1**
Total Kjeldahl Nitrogen (TKN) (mg/L)	-	-		**0.72**	-	**0.54**	-	
Total Nitrogen (mg/L)	**0.35**	**0.779**	**1.09**	**2.01**	**1.29**	**1.5**	**0.724**	**1.31**
Anions								
Chloride (mg/L)	**246**	**214**	**261**	**65.4**	**67.8**	**83.2**	**96.4**	**97.3**
Sulfate (mg/L)	**5.7**	<5	**5.4**	**14.1**	**16.2**	**12.1**	**10**	**8.3**
Elements								
Dissolved Iron (mg/L)	**0.119**	<0.1	**-**	**0.115**	-	**0.147**	<0.1	**-**
Dissolved Manganese (mg/L)	**0.529**	**0.062**	**-**	**0.126**	-	**0.196**	**0.114**	**-**
Boron (mg/L)	-	-		<0.05	-	<0.05	-	
Sodium (mg/L)	-	-		-	-	**53.7**	-	
Other								
DOC (mg/L)	**1.08**	**0.668**	**0.722**	<0.5	**0.866**	**0.862**	**0.959**	**0.78**
Methane (µg/L)	-	-		<2	-	-	-	
Alkalinity as CaCO3 (mg/L)	-	-		-	-	**14**	-	

Notes:

NS - Not Sampled

Bold - detected above the Minimum Detection Limit

D -Duplicate

1. DO was measured in the field as DO(%) and was converted using the online tool at: http://www.hbuehrer.ch/Rechner/O2satur.html

2. MW-12C references "MW-12" that was installed as part of the Nauset Regional Middle School monitoring well network.

3. Existing wells (MW-4, MW-8, MW-12C) screen elevations were determined based on field measurement of depth to bottom of well. Actual screen depths may vary if bottom was affected by silt build-up in well.

4. MW-12C (existing) was damaged during snow removal at the site. A sample was unable to be taken during the Quarter 1 and 2 Sampling Events.

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Figures

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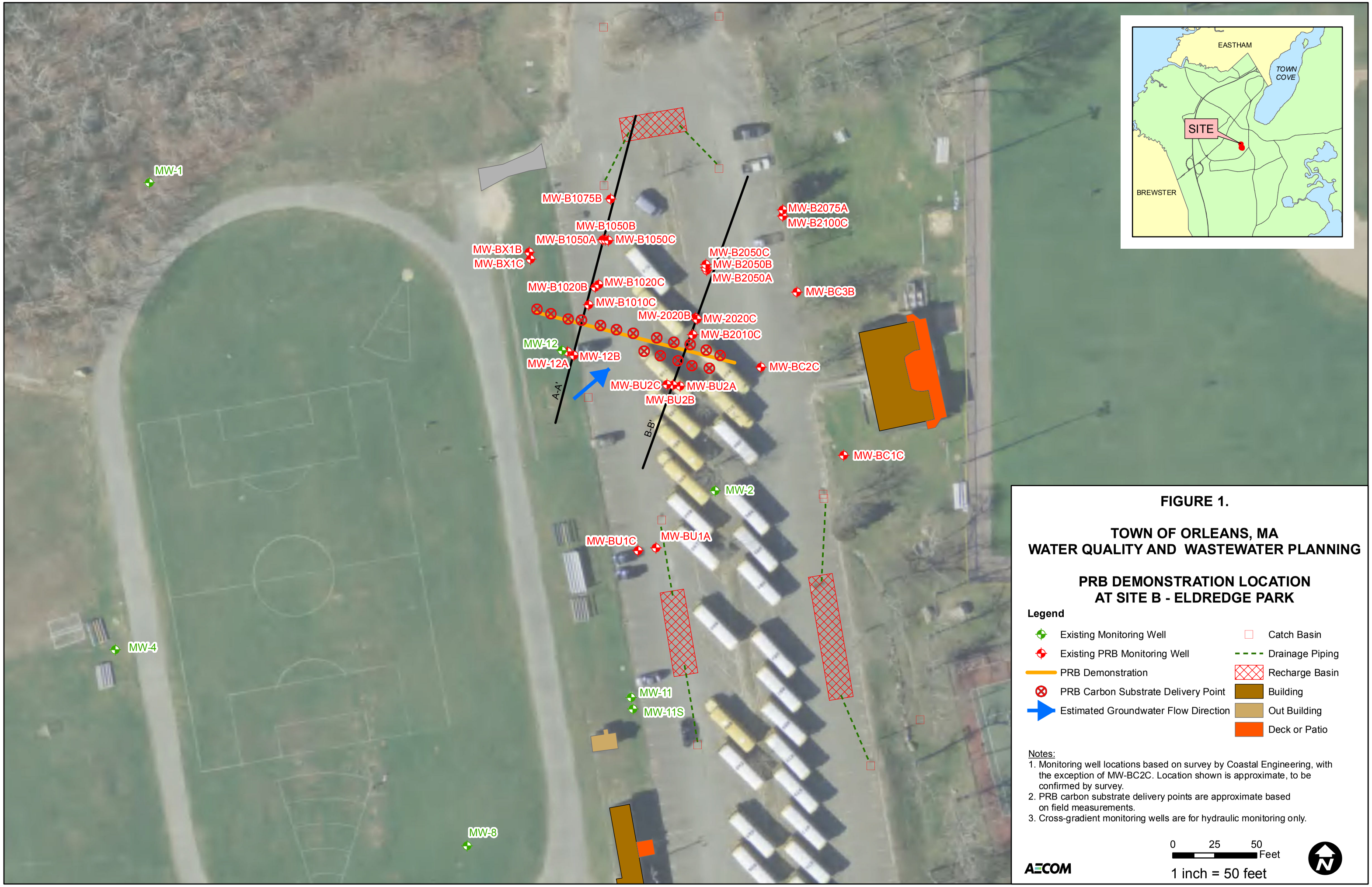


FIGURE 1.

TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING

PRB DEMONSTRATION LOCATION AT SITE B - ELDREDGE PARK

Legend

- Existing Monitoring Well
- Existing PRB Monitoring Well
- PRB Demonstration
- PRB Carbon Substrate Delivery Point
- Estimated Groundwater Flow Direction
- Catch Basin
- Drainage Piping
- Recharge Basin
- Building
- Out Building
- Deck or Patio

Notes:
1. Monitoring well locations based on survey by Coastal Engineering, with the exception of MW-BC2C. Location shown is approximate, to be confirmed by survey.
2. PRB carbon substrate delivery points are approximate based on field measurements.
3. Cross-gradient monitoring wells are for hydraulic monitoring only.

0 25 50 Feet

1 inch = 50 feet

AECOM

G:\Projects\MUNI\60476644\ORL\Maps\PRB_Figure1_EldredgePark.mxd

A
SOUTHWEST

A'
NORTHEAST

MW-12B
MW-12
MW-12A
MW-B1010C
MW-B1020B
MW-B1020C
MW-B1050A
MW-B1050B
MW-B1050C
MW-B1075B

Approximate
Ground Surface

Approximate
Water Table

Approximate
Groundwater
Flow Direction

Unsaturated
Zone

Saturated
Zone

PRB
INJECTION
ZONE

MW-12
EL. 5.12

EL. -4.90

MW-12B
EL. -9.90

EL. -19.90

MW-12A
EL. -24.40

EL. -34.90

MW-B1010C
EL. 0

EL. -10.90

MW-B1020C
EL. 4.80

EL. -5.20

MW-B1020B
EL. -10.10

EL. -20.10

MW-B1050C
EL. 4.60

EL. -5.40

MW-B1050B
EL. -10.40

EL. -20.40

MW-B1050A
EL. -35.40

EL. -35.40

MW-B1075B
EL. -10.40

EL. -20.40

Elevation (ft)
40
30
20
10
0
-10
-20
-30
-40

Feet Below Ground Surface
0
-5
-15
-25
-35
-45
-55
-65
-75
-85

Horizontal Scale (ft)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
138

Project Management Initials: Designer: Checked: Approved: ANSI B 11" x 17"

Last saved by: BOURDEAUJ (2017-02-27) Last Plotted: 2017-02-27
Filename: P:\JOBS\NDL_SERVICE\PROJECT FILES\ORLEANS\CROSS_SECTIONS.DWG

AECOM
Figure: 2

CROSS SECTION A-A'
WATER QUALITY AND WASTEWTER PLANNING
TOWN OF ORLEANS, MA
Project No.: 60476644 Date: 2017-01-23

B
SOUTHWEST

B'
NORTHEAST

MW-BU2C
MW-BU2B
MW-BU2A
MW-B2010C
MW-B2020C
MW-B2020B
MW-B2050A
MW-B2050B
MW-B2050C
MW-B2100

Approximate
Ground Surface

Unsaturated
Zone

Approximate
Water Table

Approximate
Groundwater
Flow Direction

MW-BU2C
EL. 5.12

EL. -4.90

MW-BU2B
EL. -9.90

EL. -19.90

MW-BU2A
EL. -24.40

EL. -34.90

PRB
INJECTION
ZONE

MW-B2010C
EL. 0

EL. -10.90

MW-B2020C
EL. 4.80

EL. -5.20

MW-B2020B
EL. -10.10

EL. -20.10

MW-B2050C
EL. 4.60

EL. -5.40

MW-B2050B
EL. -10.40

EL. -20.40

MW-B2050A
EL. -35.40

EL. -35.40

MW-B2100
EL. 10.00

EL. 0

Saturated
Zone

Elevation (ft)
40
30
20
10
0
-10
-20
-30
-40

Feet Below Ground Surface
0
-5
-15
-25
-35
-45
-55
-65
-75
-85

0 10 20 30 40 50 60 70 80 90 100 110 120 130
Horizontal Scale (ft)

AECOM
Figure: 3

CROSS SECTION B-B'
WATER QUALITY AND WASTEWTER PLANNING
TOWN OF ORLEANS, MA
Project No.: 60476644 Date: 2017-01-23

Project Management Initials: Designer: Checked: Approved: ANSI B 11" x 17"

Last saved by: BOURDEAUJ (2017-01-30) Last Plotted: 2017-02-27
Filename: P:\JOBS\IND1_SERVICE\PROJECT FILES\ORLEANS\CROSS_SECTIONS.DWG

A
SOUTHWEST

A'
NORTHEAST

MW-12B
MW-12
MW-12A
MW-B1010C
MW-B1020B
MW-B1020C
Approximate Ground Surface
MW-B1050A
MW-B1050B
MW-B1050C
MW-B1075B

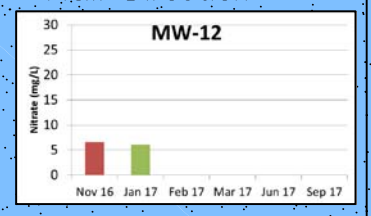
Unsaturated Zone

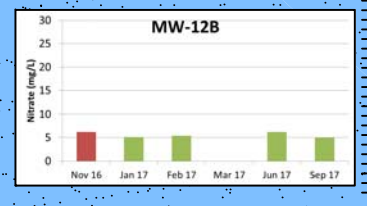
Approximate Water Table

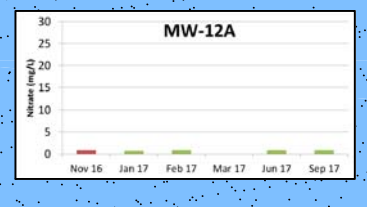
Approximate Groundwater Flow Direction

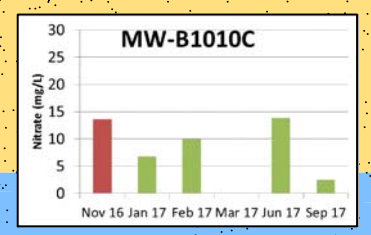
PRB INJECTION ZONE

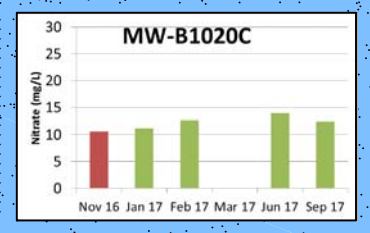
Saturated Zone

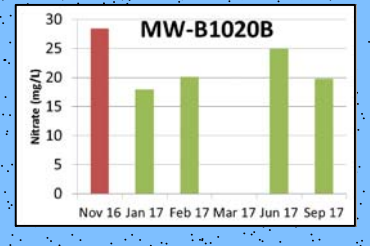


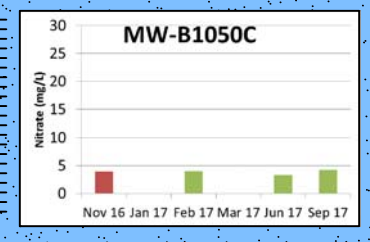


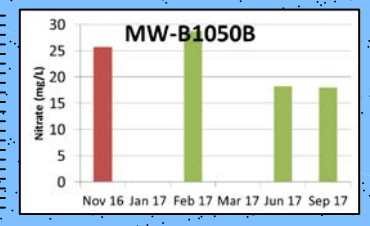


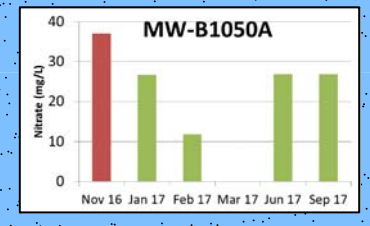


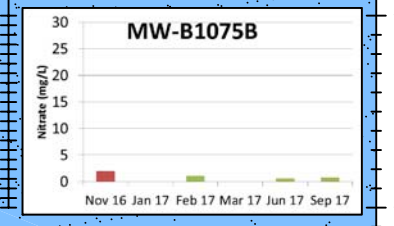












Elevation (ft)
40
30
20
10
0
−10
−20
−30
−40

Feet Below Ground Surface
0
−5
−15
−25
−35
−45
−55
−65
−75
−85

0 10 20 30 40 50 60 70 80 90 100 110 120 130 138
Horizontal Scale (ft)

CROSS SECTION A-A'
WITH NITRATE CONCENTRATION DATA
TOWN OF ORLEANS, MA
Project No.: 60476644 Date: 2017-12-04

AECOM
Figure: 4

Project Management Initials: Designer: Checked: Approved: ANSI B 11" x 17"

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B
SOUTHWEST

B'
NORTHEAST

MW-BU2C
MW-BU2B
MW-BU2A
MW-B2010C
MW-B2020C
MW-B2020B
MW-B2050A
MW-B2050B
MW-B2050C
MW-B2100
MW-B2075A

Approximate
Ground Surface

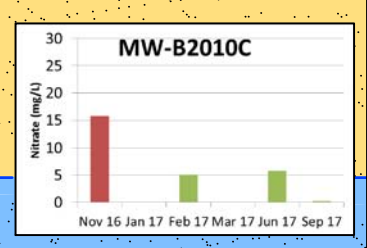
Approximate
Water Table

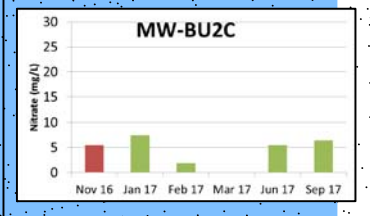
Unsaturated
Zone

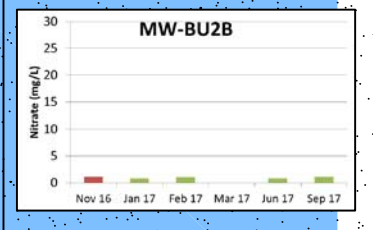
Saturated
Zone

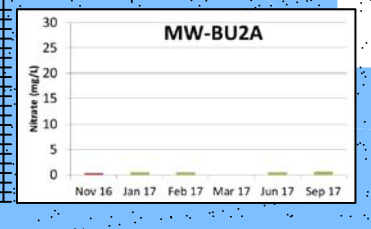
PRB
INJECTION
ZONE

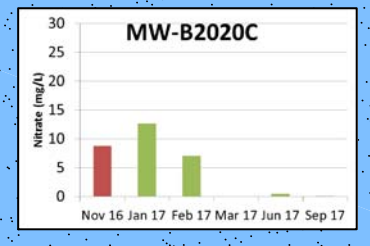
Approximate
Groundwater
Flow Direction

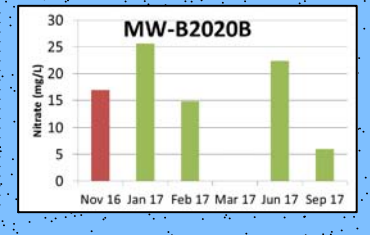


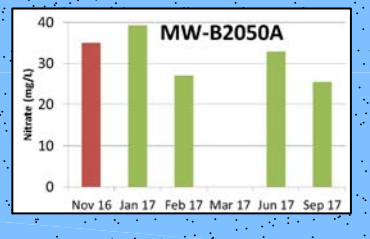


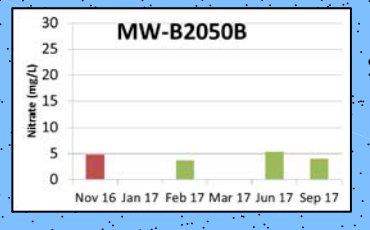


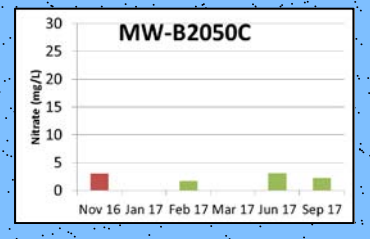


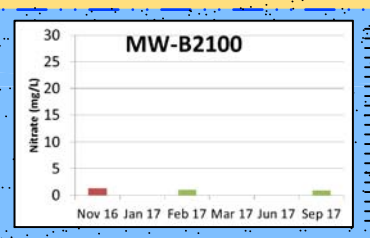


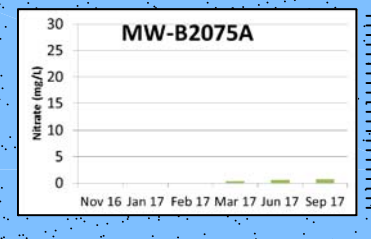












Elevation (ft)
40 30 20 10 0 −10 −20 −30 −40

Feet Below Ground Surface
0 −5 −15 −25 −35 −45 −55 −65 −75 −85

0 10 20 30 40 50 60 70 80 90 100 110 120 130
Horizontal Scale (ft)

CROSS SECTION B-B'
WITH NITRATE CONCENTRATION DATA
TOWN OF ORLEANS, MA
Project No.: 60476644 Date: 2017-12-04

AECOM
Figure: 5

Project Management Initials: Designer:____ Checked:____ Approved:____ ANSI B 11" x 17"

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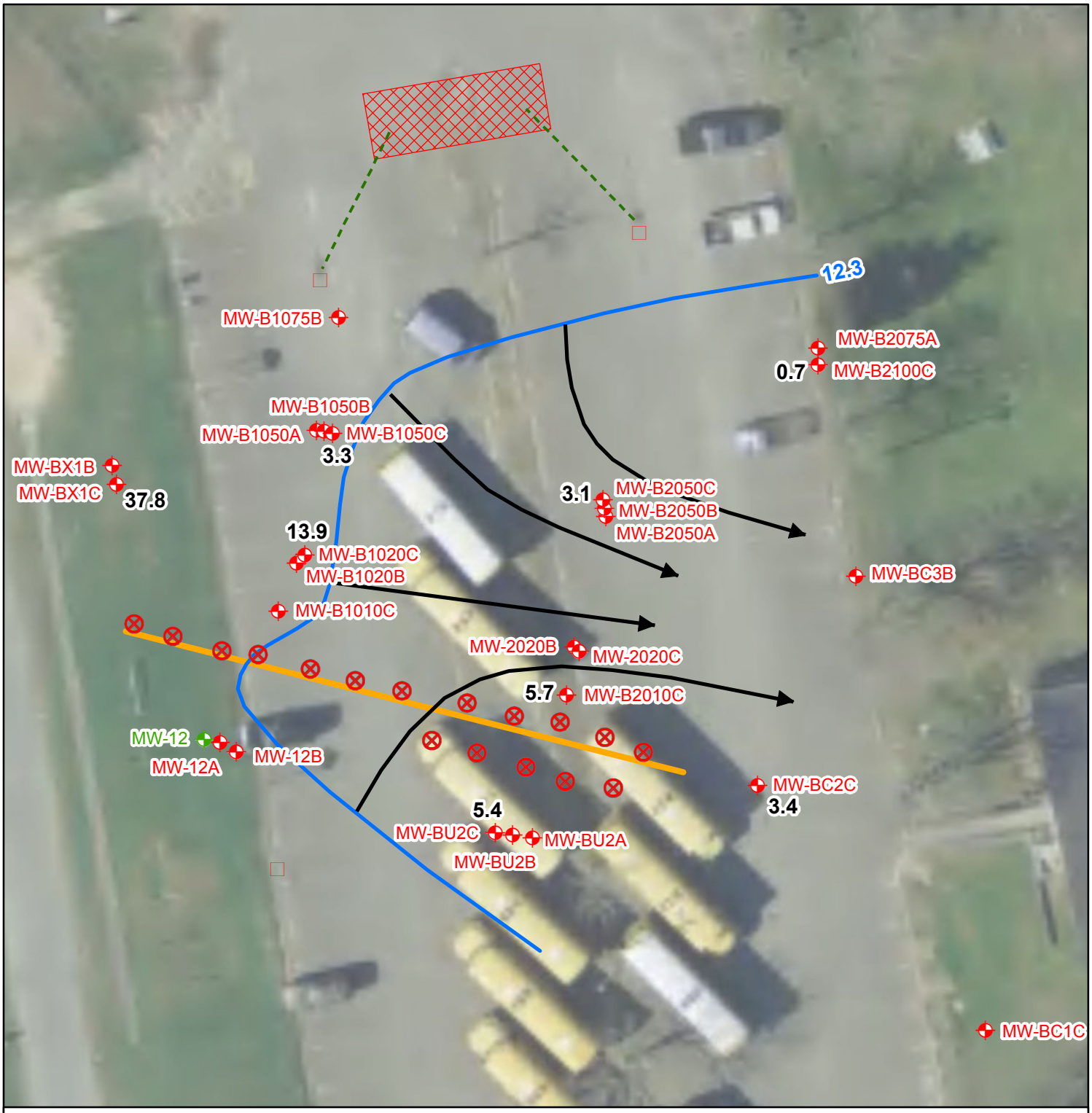

Legend

- Existing Monitoring Well
- Existing PRB Monitoring Well
- PRB Carbon Substrate Delivery Point
- PRB Demonstration
- June 2017 Shallow Groundwater Contour
- June 2017 Shallow Groundwater Flowline
- Catch Basin
- Drainage Piping
- Recharge Basin

FIGURE 6.

TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING

JUNE 2017 SHALLOW GROUNDWATER CONTOURS, FLOWLINES, AND NITRATE CONCENTRATIONS

0 20 40 Feet

1 inch = 30 feet

AECOM

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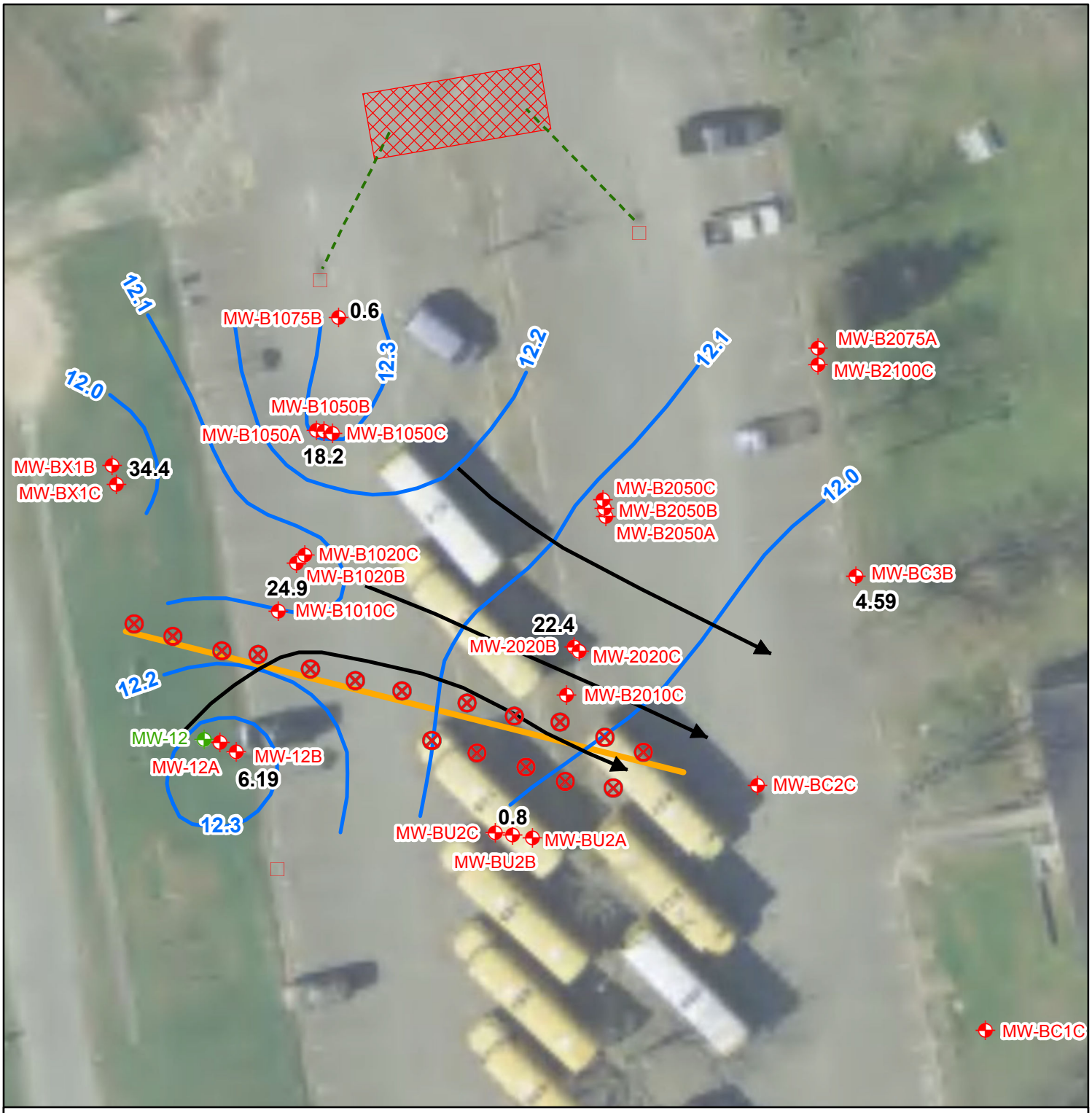

Legend

- Existing Monitoring Well
- Existing PRB Monitoring Well
- PRB Carbon Substrate Delivery Point
- PRB Demonstration
- June 2017 Intermediate Groundwater Contour
- June 2017 Intermediate Groundwater Flowline
- Catch Basin
- Drainage Piping
- Recharge Basin

FIGURE 7.

TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING

JUNE 2017 INTERMEDIATE GROUNDWATER CONTOURS, FLOWLINES, AND NITRATE CONCENTRATIONS

0 20 40 Feet

1 inch = 30 feet

AECOM

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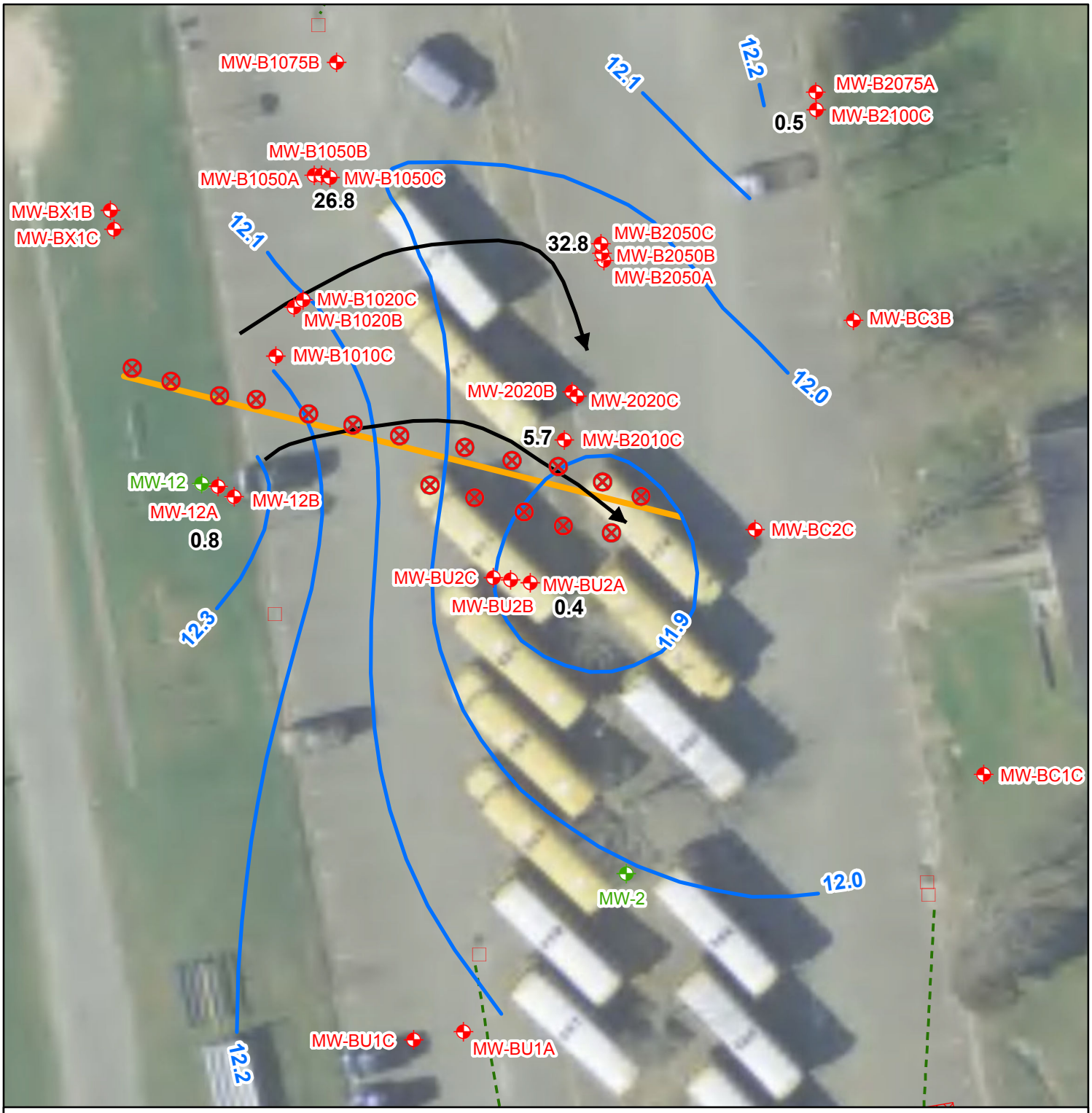

Legend

- Existing Monitoring Well
- Existing PRB Monitoring Well
- PRB Carbon Substrate Delivery Point
- PRB Demonstration
- June 2017 Deep Groundwater Contour
- June 2017 Deep Groundwater Flowline
- Catch Basin
- Drainage Piping
- Recharge Basin

FIGURE 8.

TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING

JUNE 2017 DEEP GROUNDWATER CONTOURS, FLOWLINES, AND NITRATE CONCENTRATIONS

0 20 40 Feet

1 inch = 30 feet

AECOM

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FIGURE 9.

TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING

SEPTEMBER 2017 SHALLOW GROUNDWATER CONTOURS AND NITRATE CONCENTRATIONS

Legend

- Existing NRMS Monitoring Well
- Existing PRB Monitoring Well
- PRB Demonstration
- PRB Carbon Substrate Delivery Point
- 12:2 Groundwater Contour
- Catch Basin
- Drainage Piping
- Recharge Basin
- Building
- Out Building
- Deck or Patio

NOTES:
NRMS - Nauset Regional Middle School
Groundwater Contours are in Feet Elevation - NAVD88 Datum
6.35 Nitrate as N (mg/L)

0 25 50 Feet

1 inch = 50 feet

AECOM

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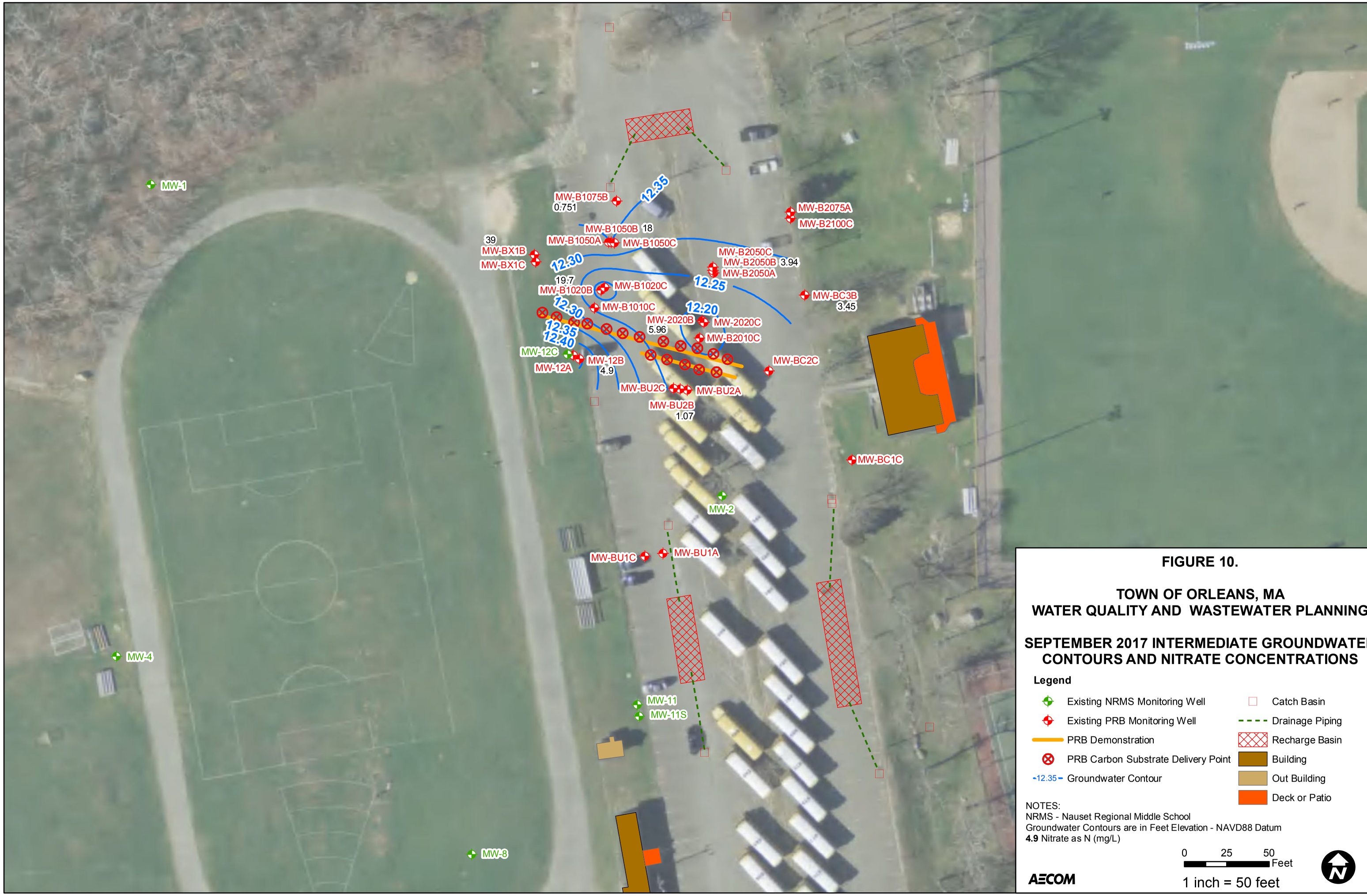

FIGURE 10.

TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING

SEPTEMBER 2017 INTERMEDIATE GROUNDWATER CONTOURS AND NITRATE CONCENTRATIONS

Legend

- Existing NRMS Monitoring Well
- Existing PRB Monitoring Well
- PRB Demonstration
- PRB Carbon Substrate Delivery Point
- 12.35 Groundwater Contour
- Catch Basin
- Drainage Piping
- Recharge Basin
- Building
- Out Building
- Deck or Patio

NOTES:
NRMS - Nauset Regional Middle School
Groundwater Contours are in Feet Elevation - NAVD88 Datum
4.9 Nitrate as N (mg/L)

0 25 50 Feet

1 inch = 50 feet

AECOM

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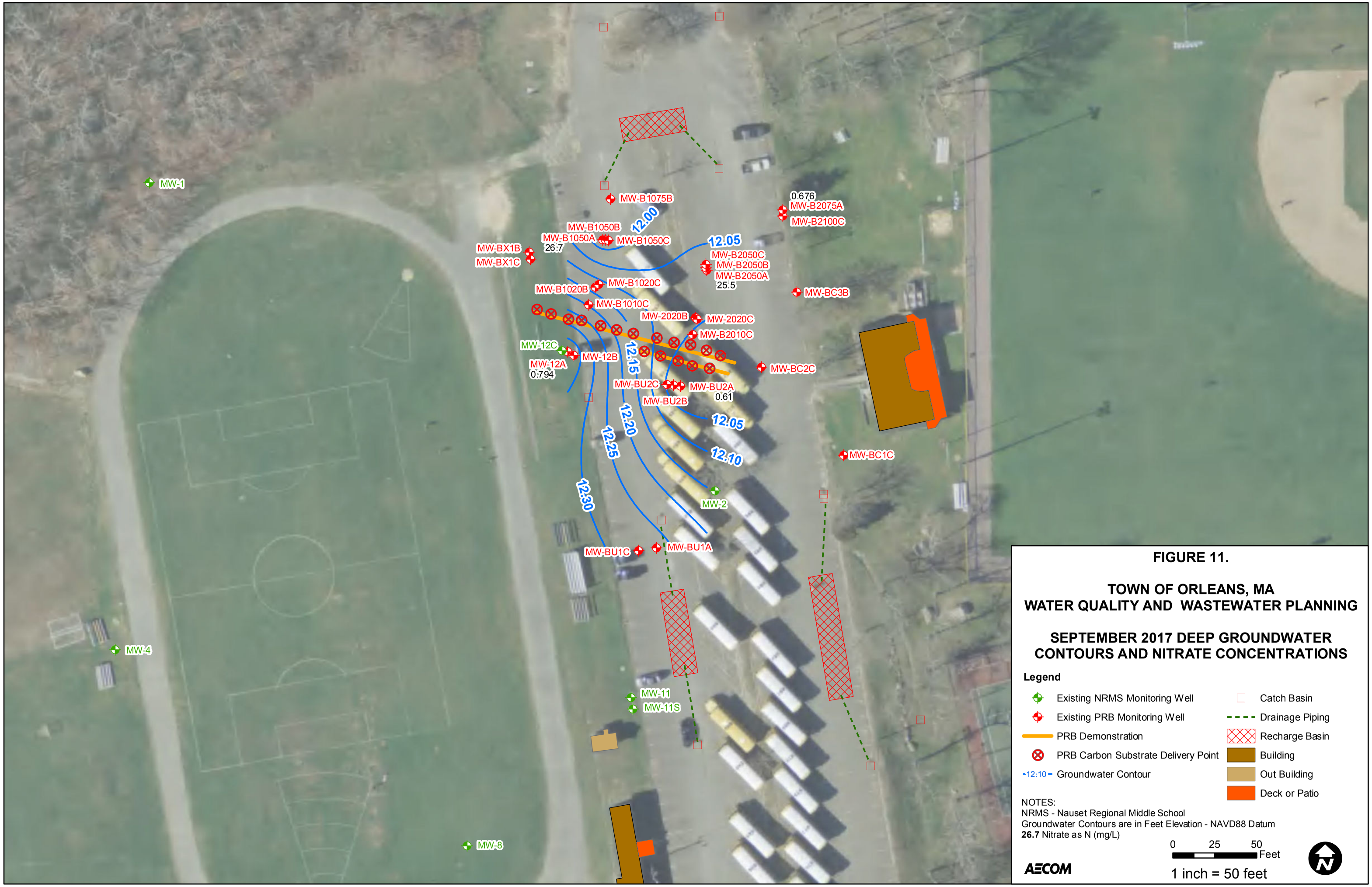

FIGURE 11.

TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING

SEPTEMBER 2017 DEEP GROUNDWATER CONTOURS AND NITRATE CONCENTRATIONS

Legend

- Existing NRMS Monitoring Well
- Existing PRB Monitoring Well
- PRB Demonstration
- PRB Carbon Substrate Delivery Point
- 12:10 Groundwater Contour
- Catch Basin
- Drainage Piping
- Recharge Basin
- Building
- Out Building
- Deck or Patio

NOTES:
NRMS - Nauset Regional Middle School
Groundwater Contours are in Feet Elevation - NAVD88 Datum
26.7 Nitrate as N (mg/L)

0 25 50 Feet

1 inch = 50 feet

AECOM

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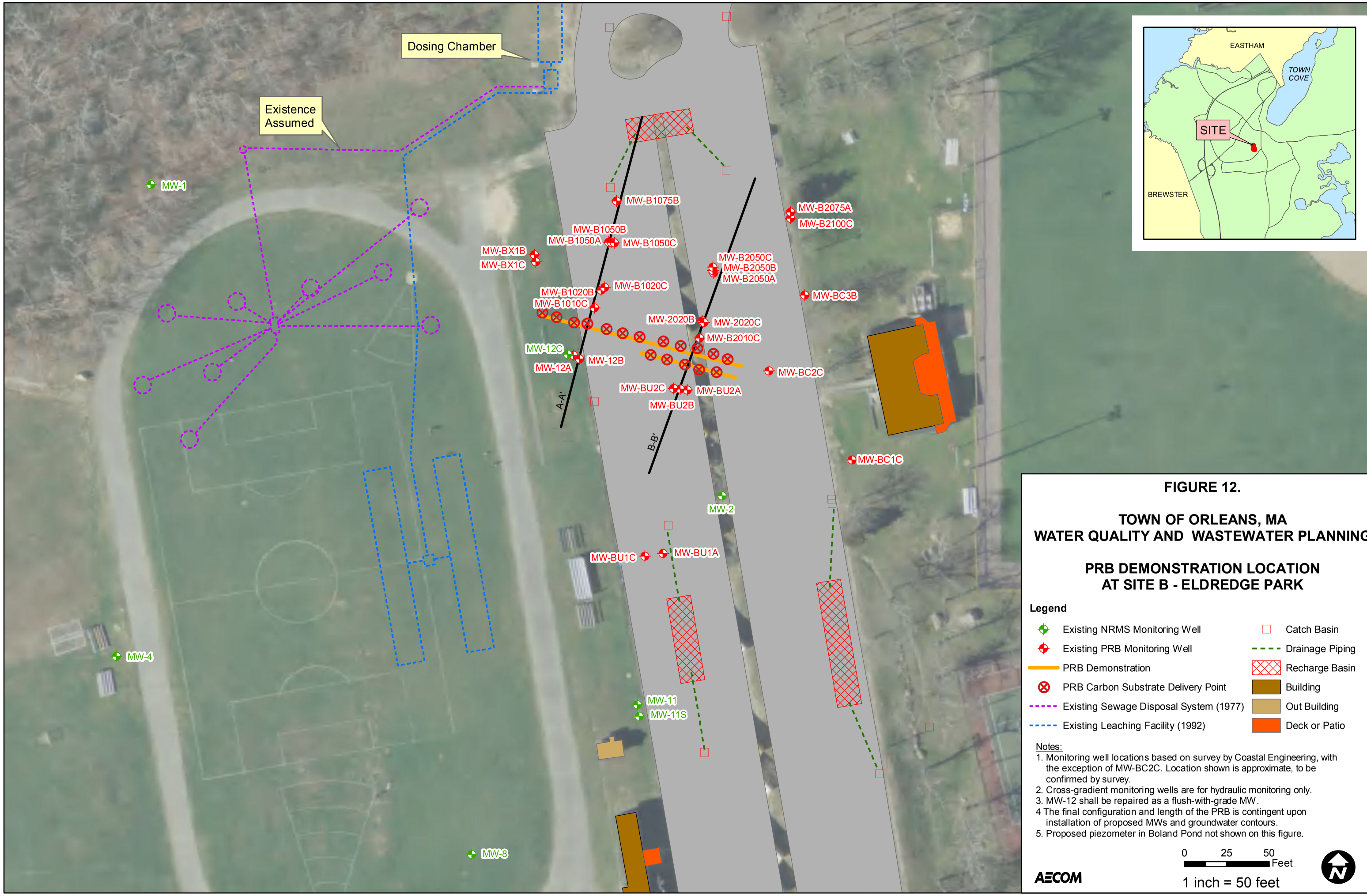

FIGURE 12.

TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING

PRB DEMONSTRATION LOCATION
AT SITE B - ELDREDGE PARK

Legend

- Existing NRMS Monitoring Well
- Existing PRB Monitoring Well
- PRB Demonstration
- PRB Carbon Substrate Delivery Point
- Existing Sewage Disposal System (1977)
- Existing Leaching Facility (1992)
- Catch Basin
- Drainage Piping
- Recharge Basin
- Building
- Out Building
- Deck or Patio

Notes:
1. Monitoring well locations based on survey by Coastal Engineering, with the exception of MW-BC2C. Location shown is approximate, to be confirmed by survey.
2. Cross-gradient monitoring wells are for hydraulic monitoring only.
3. MW-12 shall be repaired as a flush-with-grade MW.
4 The final configuration and length of the PRB is contingent upon installation of proposed MWs and groundwater contours.
5. Proposed piezometer in Boland Pond not shown on this figure.

0 25 50 Feet

1 inch = 50 feet

AECOM

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Appendix A

Monitoring Well Coordinates

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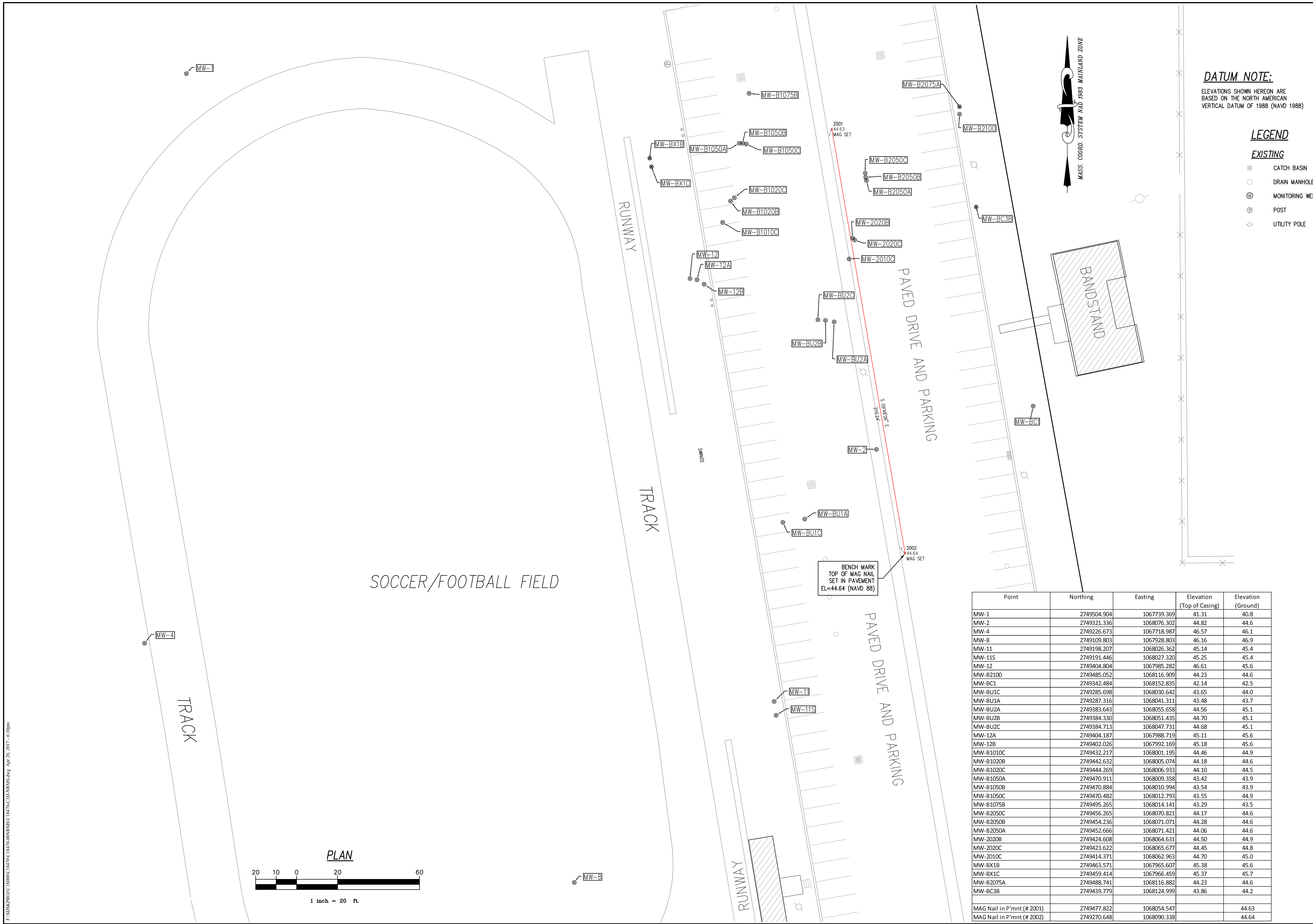

DATUM NOTE:

ELEVATIONS SHOWN HEREON ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 1988)

LEGEND

EXISTING

- CATCH BASIN
- DRAIN MANHOLE
- MONITORING WELL
- POST
- UTILITY POLE

Point	Northing	Easting	Elevation (Top of Casing)	Elevation (Ground)
MW-1	2749504.904	1067739.369	41.31	40.8
MW-2	2749321.336	1068076.302	44.82	44.6
MW-4	2749226.673	1067718.987	46.57	46.1
MW-8	2749109.803	1067928.803	46.16	46.9
MW-11	2749198.207	1068026.362	45.14	45.4
MW-11S	2749191.446	1068027.320	45.25	45.4
MW-12	2749404.804	1067985.282	46.61	45.6
MW-B2100	2749485.052	1068116.909	44.23	44.6
MW-BC1	2749342.484	1068152.835	42.14	42.5
MW-BU1C	2749285.698	1068030.642	43.65	44.0
MW-BU1A	2749287.316	1068041.311	43.48	43.7
MW-BU2A	2749383.643	1068055.658	44.56	45.1
MW-BU2B	2749384.330	1068051.435	44.70	45.1
MW-BU2C	2749384.713	1068047.731	44.68	45.1
MW-12A	2749404.187	1067988.719	45.11	45.6
MW-12B	2749402.026	1067992.169	45.18	45.6
MW-B1010C	2749432.217	1068001.195	44.46	44.9
MW-B1020B	2749442.632	1068005.074	44.18	44.6
MW-B1020C	2749444.269	1068006.933	44.10	44.5
MW-B1050A	2749470.911	1068009.358	43.42	43.9
MW-B1050B	2749470.884	1068010.994	43.54	43.9
MW-B1050C	2749470.482	1068012.793	43.55	44.9
MW-B1075B	2749495.265	1068014.141	43.29	43.5
MW-B2050C	2749456.265	1068070.821	44.17	44.6
MW-B2050B	2749454.236	1068071.071	44.28	44.6
MW-B2050A	2749452.666	1068071.421	44.06	44.6
MW-2020B	2749424.608	1068064.631	44.50	44.9
MW-2020C	2749423.622	1068065.677	44.45	44.8
MW-2010C	2749414.371	1068062.963	44.70	45.0
MW-BX1B	2749463.571	1067965.607	45.38	45.6
MW-BX1C	2749459.414	1067966.459	45.37	45.7
MW-B2075A	2749488.741	1068116.882	44.23	44.6
MW-BC3B	2749439.779	1068124.999	43.86	44.2
MAG Nail in P'mnt (# 2001)	2749477.822	1068054.547		44.63
MAG Nail in P'mnt (# 2002)	2749270.648	1068090.338		44.64

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

NO.	DATE	REVISION	BY

SEAL

PROJECT
AECOM
NAUSET REGIONAL MIDDLE SCHOOL - OFF ELDREDGE PARK WAY
ORLEANS, MA

SHEET TITLE
WELL PLAN OF LAND
SHOWING MONITOR WELL LOCATIONS

SCALE AS NOTED
DRAWING FILE C18470-C3D-NRMS.dwg
DATE REV 4/20/2017 ~~1/26/2017~~
DRAWN BY BPM
CHECKED BY

SKC-5

1 OF 1 SHEETS
PROJECT NO. C18470.00

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Appendix B

Analytical Laboratory Reports

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CERTIFICATE OF ANALYSIS

Mark Owen
AECOM Environment - ENSR
9 Jonathon Bourne Dr.
Pocasset, MA 02559

RE: Orleans MA (60476644.11.1.B.2.A)
ESS Laboratory Work Order Number: 1709283

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 1:59 pm, Sep 21, 2017

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1709283

SAMPLE RECEIPT

The following samples were received on September 13, 2017 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
1709283-01	MW-B1010C	Ground Water	200.7, 350.1, 353.2, 4500N, 4500NO2 B, 5310B, 9038, 9250
1709283-02	MW-B1020B	Ground Water	200.7, 350.1, 353.2, 4500N, 4500NO2 B, 5310B, 9038, 9250
1709283-03	MW-B1020C	Ground Water	200.7, 350.1, 353.2, 4500N, 4500NO2 B, 5310B, 9038, 9250
1709283-04	MW-B1050C	Ground Water	350.1, 353.2, 4500N, 4500NO2 B, 5310B, 9038, 9250
1709283-05	MW-B1050B	Ground Water	350.1, 353.2, 4500N, 4500NO2 B, 5310B, 9038, 9250
1709283-06	MW-B1050A	Ground Water	350.1, 353.2, 4500N, 4500NO2 B, 5310B, 9038, 9250
1709283-07	MW-BX1C	Ground Water	350.1, 353.2, 4500N, 4500NO2 B, 5310B, 9038, 9250
1709283-08	MW-BX1B	Ground Water	350.1, 353.2, 4500N, 4500NO2 B, 5310B, 9038, 9250
1709283-09	MW-12A	Ground Water	350.1, 353.2, 4500N, 4500NO2 B, 5310B, 9038, 9250
1709283-10	MW-12B	Ground Water	350.1, 353.2, 4500N, 4500NO2 B, 5310B, 9038, 9250
1709283-11	MW-BU2A	Ground Water	350.1, 353.2, 4500N, 4500NO2 B, 5310B, 9038, 9250
1709283-12	MW-BU2B	Ground Water	350.1, 353.2, 4500N, 4500NO2 B, 5310B, 9038, 9250

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
ESS Laboratory Work Order: 1709283

1709283-13	MW-BU2C	Ground Water	350.1, 353.2, 4500N, 4500NO2 B, 5310B, 9038, 9250
1709283-14	MW-B2075A	Ground Water	350.1, 353.2, 4500N, 4500NO2 B, 5310B, 9038, 9250
1709283-15	MW-B2100C	Ground Water	350.1, 353.2, 4500N, 4500NO2 B, 5310B, 9038, 9250

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1709283

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

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Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1709283

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH / 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-B1010C
Date Sampled: 09/12/17 10:30
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**3.88** (0.100)		200.7		1	KJK	09/14/17 0:11	10	10	CI71304
Manganese	**0.996** (0.020)		200.7		1	KJK	09/14/17 0:11	10	10	CI71304

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B1010C
Date Sampled: 09/12/17 10:30
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-01
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	ND (0.10)		350.1		1	JLK	09/18/17 17:34	mg/L	CI71521
Chloride	**23.6** (3.0)		9250		1	EEM	09/14/17 14:37	mg/L	CI71422
Dissolved Organic Carbon (Average)	**21.4** (1.00)		5310B		2	DEL	09/16/17 11:30	mg/L	[CALC]
Nitrate/Nitrite as N	**2.49** (0.100)		353.2		5	JLK	09/14/17 17:32	mg/L	CI71439
Nitrite as N	**0.185** (0.010)		4500NO2 B		1	JLK	09/13/17 22:58	mg/L	CI71326
Sulfate	**22.6** (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71942
Total Nitrogen	**4.22** (0.300)		4500N		5	EEM	09/18/17 16:09	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B1020B
Date Sampled: 09/12/17 11:00
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	09/14/17 0:15	10	10	CI71304
Manganese	**0.320** (0.020)		200.7		1	KJK	09/14/17 0:15	10	10	CI71304

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B1020B
Date Sampled: 09/12/17 11:00
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-02
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	09/18/17 17:34	mg/L	CI71521
Chloride	**30.0** (3.0)		9250		1	EEM	09/14/17 14:37	mg/L	CI71422
Dissolved Organic Carbon (Average)	**3.67** (0.500)		5310B		1	DEL	09/15/17 21:51	mg/L	[CALC]
Nitrate/Nitrite as N	**19.7** (0.400)		353.2		20	JLK	09/14/17 17:35	mg/L	CI71439
Nitrite as N	**0.076** (0.010)		4500NO2 B		1	JLK	09/13/17 22:58	mg/L	CI71326
Sulfate	ND (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71942
Total Nitrogen	**19.7** (0.600)		4500N		20	EEM	09/18/17 16:10	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B1020C
Date Sampled: 09/12/17 11:40
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-03
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	09/14/17 0:19	10	10	CI71304
Manganese	**0.042** (0.020)		200.7		1	KJK	09/14/17 0:19	10	10	CI71304

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B1020C
Date Sampled: 09/12/17 11:40
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-03
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	ND (0.10)		350.1		1	JLK	09/18/17 17:35	mg/L	CI71521
Chloride	**24.1** (3.0)		9250		1	EEM	09/14/17 14:38	mg/L	CI71422
Dissolved Organic Carbon (Average)	**2.19** (0.500)		5310B		1	DEL	09/15/17 21:31	mg/L	[CALC]
Nitrate/Nitrite as N	**12.4** (0.400)		353.2		20	JLK	09/14/17 17:36	mg/L	CI71439
Nitrite as N	ND (0.010)		4500NO2 B		1	JLK	09/13/17 22:58	mg/L	CI71326
Sulfate	**5.8** (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71942
Total Nitrogen	**12.4** (0.600)		4500N		20	EEM	09/18/17 16:11	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B1050C
Date Sampled: 09/12/17 12:20
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-04
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	09/18/17 17:38	mg/L	CI71521
Chloride	**120** (6.0)		9250		2	EEM	09/14/17 14:54	mg/L	CI71422
Dissolved Organic Carbon (Average)	**2.19** (0.500)		5310B		1	DEL	09/15/17 21:43	mg/L	[CALC]
Nitrate/Nitrite as N	**4.18** (0.200)		353.2		10	JLK	09/14/17 17:37	mg/L	CI71439
Nitrite as N	ND (0.010)		4500NO2 B		1	JLK	09/13/17 22:58	mg/L	CI71326
Sulfate	**14.6** (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71942
Total Nitrogen	**4.40** (0.400)		4500N		10	EEM	09/18/17 16:12	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B1050B
Date Sampled: 09/12/17 12:40
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-05
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	**0.14** (0.10)		350.1		1	JLK	09/18/17 17:40	mg/L	CI71521
Chloride	**38.2** (3.0)		9250		1	EEM	09/14/17 14:39	mg/L	CI71422
Dissolved Organic Carbon (Average)	**3.43** (0.500)		5310B		1	DEL	09/15/17 22:21	mg/L	[CALC]
Nitrate/Nitrite as N	**18.0** (0.400)		353.2		20	JLK	09/14/17 17:38	mg/L	CI71439
Nitrite as N	ND (0.010)		4500NO2 B		1	JLK	09/13/17 22:58	mg/L	CI71326
Sulfate	ND (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71942
Total Nitrogen	**18.0** (0.600)		4500N		20	EEM	09/18/17 16:12	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B1050A
Date Sampled: 09/12/17 13:15
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-06
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	**1.24** (0.10)		350.1		1	JLK	09/18/17 17:41	mg/L	CI71521
Chloride	**41.4** (3.0)		9250		1	EEM	09/14/17 14:40	mg/L	CI71422
Dissolved Organic Carbon (Average)	**3.72** (0.500)		5310B		1	DEL	09/15/17 22:49	mg/L	[CALC]
Nitrate/Nitrite as N	**26.7** (2.00)		353.2		100	JLK	09/14/17 17:56	mg/L	CI71439
Nitrite as N	**0.048** (0.010)		4500NO2 B		1	JLK	09/13/17 22:58	mg/L	CI71326
Sulfate	ND (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71942
Total Nitrogen	**26.7** (2.20)		4500N		100	EEM	09/18/17 16:13	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BX1C
Date Sampled: 09/12/17 13:40
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-07
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	**0.22** (0.10)		350.1		1	JLK	09/18/17 17:42	mg/L	CI71521
Chloride	**37.3** (3.0)		9250		1	EEM	09/14/17 14:40	mg/L	CI71422
Dissolved Organic Carbon (Average)	**2.69** (0.500)		5310B		1	DEL	09/15/17 22:46	mg/L	[CALC]
Nitrate/Nitrite as N	**37.8** (1.00)		353.2		50	JLK	09/14/17 17:40	mg/L	CI71439
Nitrite as N	ND (0.010)		4500NO2 B		1	JLK	09/13/17 22:58	mg/L	CI71326
Sulfate	ND (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71942
Total Nitrogen	**37.8** (1.20)		4500N		50	EEM	09/18/17 16:20	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BX1B
Date Sampled: 09/12/17 14:10
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-08
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	**0.39** (0.10)		350.1		1	JLK	09/18/17 17:42	mg/L	CI71521
Chloride	**37.9** (3.0)		9250		1	EEM	09/14/17 14:41	mg/L	CI71422
Dissolved Organic Carbon (Average)	**2.31** (0.500)		5310B		1	DEL	09/15/17 22:59	mg/L	[CALC]
Nitrate/Nitrite as N	**39.0** (1.00)		353.2		50	JLK	09/14/17 17:40	mg/L	CI71439
Nitrite as N	ND (0.010)		4500NO2 B		1	JLK	09/13/17 22:58	mg/L	CI71326
Sulfate	ND (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71942
Total Nitrogen	**39.0** (1.20)		4500N		50	EEM	09/18/17 16:21	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-12A
Date Sampled: 09/12/17 15:00
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-09
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	ND (0.10)		350.1		1	JLK	09/18/17 17:43	mg/L	CI71521
Chloride	**146** (6.0)		9250		2	EEM	09/14/17 14:55	mg/L	CI71422
Dissolved Organic Carbon (Average)	**0.792** (0.500)		5310B		1	DEL	09/15/17 23:11	mg/L	[CALC]
Nitrate/Nitrite as N	**0.794** (0.020)		353.2		1	JLK	09/14/17 17:46	mg/L	CI71439
Nitrite as N	ND (0.010)		4500NO2 B		1	JLK	09/13/17 22:58	mg/L	CI71326
Sulfate	**12.3** (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71942
Total Nitrogen	**1.11** (0.220)		4500N		1	EEM	09/18/17 16:21	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-12B
Date Sampled: 09/12/17 15:45
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-10
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	**0.26** (0.10)		350.1		1	JLK	09/18/17 17:44	mg/L	CI71521
Chloride	**50.5** (3.0)		9250		1	EEM	09/14/17 14:43	mg/L	CI71422
Dissolved Organic Carbon (Average)	**1.10** (0.500)		5310B		1	DEL	09/15/17 23:49	mg/L	[CALC]
Nitrate/Nitrite as N	**4.90** (0.200)		353.2		10	JLK	09/14/17 17:47	mg/L	CI71439
Nitrite as N	ND (0.010)		4500NO2 B		1	JLK	09/13/17 22:58	mg/L	CI71326
Sulfate	**12.1** (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71942
Total Nitrogen	**4.90** (0.400)		4500N		10	EEM	09/18/17 16:22	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BU2A
Date Sampled: 09/12/17 16:25
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-11
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	ND (0.10)		350.1		1	JLK	09/18/17 17:45	mg/L	CI71521
Chloride	**123** (6.0)		9250		2	EEM	09/14/17 14:55	mg/L	CI71422
Dissolved Organic Carbon (Average)	**0.707** (0.500)		5310B		1	DEL	09/16/17 0:01	mg/L	[CALC]
Nitrate/Nitrite as N	**0.610** (0.020)		353.2		1	JLK	09/14/17 17:48	mg/L	CI71439
Nitrite as N	ND (0.010)		4500NO2 B		1	JLK	09/13/17 22:58	mg/L	CI71326
Sulfate	ND (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71942
Total Nitrogen	**0.834** (0.220)		4500N		1	EEM	09/18/17 16:23	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BU2B
Date Sampled: 09/12/17 16:50
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-12
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	09/18/17 17:46	mg/L	CI71521
Chloride	**93.2** (3.0)		9250		1	EEM	09/14/17 14:46	mg/L	CI71422
Dissolved Organic Carbon (Average)	**0.856** (0.500)		5310B		1	DEL	09/16/17 0:13	mg/L	[CALC]
Nitrate/Nitrite as N	**1.07** (0.040)		353.2		2	JLK	09/14/17 17:49	mg/L	CI71439
Nitrite as N	ND (0.010)		4500NO2 B		1	JLK	09/13/17 22:58	mg/L	CI71326
Sulfate	ND (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71942
Total Nitrogen	**1.07** (0.240)		4500N		2	EEM	09/18/17 16:24	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BU2C
Date Sampled: 09/12/17 17:10
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-13
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	09/18/17 18:37	mg/L	CI71804
Chloride	**174** (15.0)		9250		5	EEM	09/14/17 14:56	mg/L	CI71422
Dissolved Organic Carbon (Average)	**1.35** (0.500)		5310B		1	DEL	09/16/17 0:25	mg/L	[CALC]
Nitrate/Nitrite as N	**6.35** (0.200)		353.2		10	JLK	09/14/17 17:50	mg/L	CI71439
Nitrite as N	ND (0.010)		4500NO2 B		1	JLK	09/13/17 22:58	mg/L	CI71326
Sulfate	ND (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71942
Total Nitrogen	**6.35** (0.400)		4500N		10	EEM	09/18/17 16:25	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B2075A
Date Sampled: 09/12/17 18:10
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-14
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	09/18/17 18:38	mg/L	CI71804
Chloride	**261** (15.0)		9250		5	EEM	09/14/17 14:58	mg/L	CI71422
Dissolved Organic Carbon (Average)	**0.722** (0.500)		5310B		1	DEL	09/16/17 0:37	mg/L	[CALC]
Nitrate/Nitrite as N	**0.676** (0.020)		353.2		1	JLK	09/14/17 17:51	mg/L	CI71439
Nitrite as N	ND (0.010)		4500NO2 B		1	JLK	09/13/17 22:58	mg/L	CI71326
Sulfate	**5.4** (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71942
Total Nitrogen	**1.09** (0.220)		4500N		1	EEM	09/18/17 16:26	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B2100C
Date Sampled: 09/12/17 18:35
Percent Solids: N/A

ESS Laboratory Work Order: 1709283
ESS Laboratory Sample ID: 1709283-15
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	09/18/17 18:38	mg/L	CI71804
Chloride	**97.3** (3.0)		9250		1	EEM	09/14/17 14:48	mg/L	CI71422
Dissolved Organic Carbon (Average)	**0.780** (0.500)		5310B		1	DEL	09/16/17 1:16	mg/L	[CALC]
Nitrate/Nitrite as N	**0.903** (0.020)		353.2		1	JLK	09/14/17 17:52	mg/L	CI71439
Nitrite as N	ND (0.010)		4500NO2 B		1	JLK	09/13/17 22:58	mg/L	CI71326
Sulfate	**8.3** (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71942
Total Nitrogen	**1.31** (0.220)		4500N		1	EEM	09/18/17 16:26	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1709283

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch CI71304 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.48		mg/L	2.500		99	80-120			
Manganese	0.502		mg/L	0.5000		100	80-120			
Classical Chemistry										
Batch CI71326 - General Preparation										
Blank										
Nitrite as N	ND	0.010	mg/L							
LCS										
Nitrite as N	0.050		mg/L	0.04994		99	90-110			
Batch CI71422 - General Preparation										
Blank										
Chloride	ND	3.0	mg/L							
LCS										
Chloride	30.6		mg/L	30.00		102	90-110			
Batch CI71439 - General Preparation										
Blank										
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/Nitrite as N	0.469		mg/L	0.5000		94	90-110			
Nitrate/Nitrite as N	0.469		mg/L	0.5000		94	90-110			
Total Nitrogen	0.469		mg/L							
Batch CI71521 - NH4 Prep										
Blank										
Ammonia as N	ND	0.10	mg/L							
LCS										
Ammonia as N	0.10	0.10	mg/L	0.09994		99	80-120			
LCS										
Ammonia as N	0.92	0.10	mg/L	0.9994		92	80-120			
Batch CI71530 - 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	14.7	2.00	mg/L	14.20		103	80-120			
Total Nitrogen	14.7	2.00	mg/L							

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1709283

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Classical Chemistry										
Batch CI71536 - 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)	5.06	0.500	mg/L	5.000		101	80-120			
Dissolved Organic Carbon (2)	5.15	0.500	mg/L	5.000		103	80-120			
Dissolved Organic Carbon (Average)	5.10	0.500	mg/L							
LCS Dup										
Dissolved Organic Carbon (1)	5.21	0.500	mg/L	5.000		104	80-120	3	200	
Dissolved Organic Carbon (2)	5.21	0.500	mg/L	5.000		104	80-120	1	200	
Dissolved Organic Carbon (Average)	5.21	0.500	mg/L							
Batch CI71804 - NH4 Prep										
Blank										
Ammonia as N	ND	0.10	mg/L							
LCS										
Ammonia as N	0.11	0.10	mg/L	0.09994		112	80-120			
LCS										
Ammonia as N	1.12	0.10	mg/L	0.9994		112	80-120			
Batch CI71942 - General Preparation										
Blank										
Sulfate	ND	5.0	mg/L							
LCS										
Sulfate	9.6		mg/L	9.988		96	85-115			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1709283

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1709283

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

United States Department of Agriculture Soil Permit: P330-12-00139

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB/MM

Shipped/Delivered Via: ESS Courier

ESS Project ID: 1709283
Date Received: 9/13/2017
Project Due Date: 9/20/2017
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 5.3 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** Yes / No / NA
10. Were any analyses received outside of hold time? Yes (No)

11. Any Subcontracting needed? Yes / (No)
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / (No)
    a. Air bubbles in aqueous VOAs? Yes / No
    b. Does methanol cover soil completely? Yes / No / NA
13. Are the samples properly preserved? (Yes) / No
    a. If metals preserved upon receipt: Date: Time: By:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

COC = MW-BU2C 1710 Labels = MW-BU2C 1720 hdm 9/13/17

14. Was there a need to contact Project Manager? Yes / (No)
    a. Was there a need to contact the client? Yes / No
    Who was contacted: Date: Time: By:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
01	162287	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
01	162302	Yes	NA	Yes	500 mL Poly - Unpres	NP	
01	162305	Yes	NA	Yes	250 mL Poly - Unpres	NP	
01	162320	Yes	NA	Yes	250 mL Amber - Unpres	NP	
01	162349	Yes	NA	Yes	VOA Vial - HCl	HCl	
01	162350	Yes	NA	Yes	VOA Vial - HCl	HCl	
02	162286	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
02	162301	Yes	NA	Yes	500 mL Poly - Unpres	NP	
02	162304	Yes	NA	Yes	250 mL Poly - Unpres	NP	
02	162319	Yes	NA	Yes	250 mL Amber - Unpres	NP	
02	162347	Yes	NA	Yes	VOA Vial - HCl	HCl	
02	162348	Yes	NA	Yes	VOA Vial - HCl	HCl	
03	162285	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
03	162300	Yes	NA	Yes	500 mL Poly - Unpres	NP	
03	162303	Yes	NA	Yes	250 mL Poly - Unpres	NP	
03	162318	Yes	NA	Yes	250 mL Amber - Unpres	NP	
03	162345	Yes	NA	Yes	VOA Vial - HCl	HCl	
03	162346	Yes	NA	Yes	VOA Vial - HCl	HCl	
04	162284	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
04	162299	Yes	NA	Yes	500 mL Poly - Unpres	NP	
04	162317	Yes	NA	Yes	250 mL Amber - Unpres	NP	
04	162343	Yes	NA	Yes	VOA Vial - HCl	HCl	
04	162344	Yes	NA	Yes	VOA Vial - HCl	HCl	
05	162283	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB/MM

ESS Project ID: 1709283

Date Received: 9/13/2017

05	162298	Yes	NA	Yes	500 mL Poly - Unpres	NP
05	162316	Yes	NA	Yes	250 mL Amber - Unpres	NP
05	162341	Yes	NA	Yes	VOA Vial - HCl	HCl
05	162342	Yes	NA	Yes	VOA Vial - HCl	HCl
06	162282	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
06	162297	Yes	NA	Yes	500 mL Poly - Unpres	NP
06	162315	Yes	NA	Yes	250 mL Amber - Unpres	NP
06	162339	Yes	NA	Yes	VOA Vial - HCl	HCl
06	162340	Yes	NA	Yes	VOA Vial - HCl	HCl
07	162281	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
07	162296	Yes	NA	Yes	500 mL Poly - Unpres	NP
07	162314	Yes	NA	Yes	250 mL Amber - Unpres	NP
07	162337	Yes	NA	Yes	VOA Vial - HCl	HCl
07	162338	Yes	NA	Yes	VOA Vial - HCl	HCl
08	162280	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
08	162295	Yes	NA	Yes	500 mL Poly - Unpres	NP
08	162313	Yes	NA	Yes	250 mL Amber - Unpres	NP
08	162335	Yes	NA	Yes	VOA Vial - HCl	HCl
08	162336	Yes	NA	Yes	VOA Vial - HCl	HCl
09	162279	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
09	162294	Yes	NA	Yes	500 mL Poly - Unpres	NP
09	162312	Yes	NA	Yes	250 mL Amber - Unpres	NP
09	162333	Yes	NA	Yes	VOA Vial - HCl	HCl
09	162334	Yes	NA	Yes	VOA Vial - HCl	HCl
10	162278	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
10	162293	Yes	NA	Yes	500 mL Poly - Unpres	NP
10	162311	Yes	NA	Yes	250 mL Amber - Unpres	NP
10	162331	Yes	NA	Yes	VOA Vial - HCl	HCl
10	162332	Yes	NA	Yes	VOA Vial - HCl	HCl
11	162277	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
11	162292	Yes	NA	Yes	500 mL Poly - Unpres	NP
11	162310	Yes	NA	Yes	250 mL Amber - Unpres	NP
11	162329	Yes	NA	Yes	VOA Vial - HCl	HCl
11	162330	Yes	NA	Yes	VOA Vial - HCl	HCl
12	162276	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
12	162291	Yes	NA	Yes	500 mL Poly - Unpres	NP
12	162309	Yes	NA	Yes	250 mL Amber - Unpres	NP
12	162327	Yes	NA	Yes	VOA Vial - HCl	HCl
12	162328	Yes	NA	Yes	VOA Vial - HCl	HCl
13	162275	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
13	162290	Yes	NA	Yes	500 mL Poly - Unpres	NP
13	162308	Yes	NA	Yes	250 mL Amber - Unpres	NP
13	162325	Yes	NA	Yes	VOA Vial - HCl	HCl
13	162326	Yes	NA	Yes	VOA Vial - HCl	HCl
14	162274	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
14	162289	Yes	NA	Yes	500 mL Poly - Unpres	NP
14	162307	Yes	NA	Yes	250 mL Amber - Unpres	NP
14	162323	Yes	NA	Yes	VOA Vial - HCl	HCl
14	162324	Yes	NA	Yes	VOA Vial - HCl	HCl
15	162273	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
15	162288	Yes	NA	Yes	500 mL Poly - Unpres	NP
15	162306	Yes	NA	Yes	250 mL Amber - Unpres	NP
15	162321	Yes	NA	Yes	VOA Vial - HCl	HCl
15	162322	Yes	NA	Yes	VOA Vial - HCl	HCl

2nd Review

Are barcode labels on correct containers? Yes / No

Completed By: _____ Date & Time: 9/13/17 0926

Reviewed By: _____ Date & Time: 9/13/17 0958

Delivered By: _____ 9/13/17 1003

ESS Laboratory
Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston RI 02910
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www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 1709283

Turn Time: 5-Day Rush
Regulatory State
Is this project for any of the following?: ○CT RCP ○MA MCP ○ [illegible]
Reporting Limits
Electonic Deliverables: ☐Limit Checker ☐Standard Excel ☐Other (Please Specify →)

Company Name: AECOM	Project #: 60476644.11.1.B.2.A	Project Name: oneans PRB Quarterly	
Contact Person: Julianne Mamon	Address: 250 Apollo Drive		
City: Chelmsford	State: MA	Zip Code: 01824	PO #:
Telephone Number: 978-905-2419	FAX Number:	Email Address: Julianne.mamon@aecom.com	

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: NO_2, NO_3, TN, SO_4, Cl	Analysis: TN, NH_4	Analysis: DOC	Analysis: DISS(UF) Fe + Mn
1	09/12/17	1030	G	GW	MW-B101OC	X	X	X	X
2	09/12/17	1100	G	GW	MW-B102OB	X	X	X	X
3	09/12/17	1140	G	GW	MW-B102OC	X	X	X	X
4	09/12/17	1220	G	GW	MW-B105OC	X	X	X	
5	09/12/17	1240	G	GW	MW-B105OB	X	X	X	
6	09/12/17	1315	G	GW	MW-B105OA	X	X	X	
7	09/12/17	1340	G	GW	MW-BXIC	X	X	X	
8	09/12/17	1410	G	GW	MW-BXIB	X	X	X	
9	09/12/17	1500	G	GW	MW-12A	X	X	X	
10	09/12/17	1545	G	GW	MW-12B	X	X	X	

Container Type: AC-Air Cassette AG-Amber Glass B-BOD Bottle C-Cubitainer G-Glass O-C[illegible]r P-Poly S-Sterile V-Vial — P | P | AG | P
Container Volume: 1-100 mL 2-2.5 gal 3-250 mL 4-300 mL 5-500 mL 6-1L 7-VOA 8-2 oz 9-4 oz 10-8 oz 11-Other* — 5 | 6 | 3 | 3
Preservation Code: 1-Non Preserved 2-HCl 3-H2SO4 4-HNO3 5-NaOH 6-Methanol 7-Na2S2O3 8-ZnAce, NaO 9-NH4Cl 10-DI H2O 11-Other* — 1 | 3 | 1 | 1
Number of Containers per Sample: 1 | 1 | 1 | 1

Laboratory Use Only
Cooler Present: Y
Seals Intact: NA
Cooler Temperature: 5.3 °C Ice 9/13/17 8:20 ISPB

Sampled by: Briley Morrill

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
Briley Morrill (AECOM) 09/13/17 0705	9/13/17 0705	9/13/17 1510	9/13/17 0903
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

ESS Laboratory
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www.esslaboratory.com

CHAIN OF CUSTODY

ESS Lab # 1709283

Turn Time: 5-Day Rush
Regulatory State
Is this project for any of the following?: ○CT RCP ○MA MCP ○RGP
Reporting Limits
Electonic Deliverables ☐Limit Checker ☐Standard Excel ☐Other (Please Specify →)

Company Name: AECOM
Contact Person: Julianne Mamon
Project #: 60476044.11.1.B.2A
Project Name: Orleans PRB Quarterly
Address: 250 Apollo Drive
City: Chelmsford
State: MA
Zip Code: 01824
PO #:
Telephone Number: 978-905-2419
FAX Number:
Email Address: Julianne.mamone@aecom.com

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: NO2, NO3, TN, SO4, Cl	Analysis: TN, NH4	Analysis: DOC
11	09/12/17	1625	G	GW	MW-B12A	X	X	X
12	09/12/17	1650	G	GW	MW-B12B	X	X	X
13	09/12/17	1710	G	GW	MW-B12C	X	X	X
14	09/12/17	1810	G	GW	MW-B207SA	X	X	X
15	09/12/17	1835	G	GW	MW-B2100C	X	X	X

BKM 09/12/17

Container Type:	AC-Air Cassette	AG-Amber Glass	B-BOD Bottle	C-Cubitainer	G - Glass	O-Other	P-Poly	S-Sterile	V-Vial	P	P	AG	P
Container Volume:	1-100 mL	2-2.5 gal	3-250 mL	4-300 mL	5-500 mL	6-1L	7-VOA	8-2 oz	9-4 oz	10-8 oz	11-Other*	5	6	3	3
Preservation Code:	1-Non Preserved	2-HCl	3-H2SO4	4-HNO3	5-NaOH	6-Methanol	7-Na2S2O3	8-ZnAce, NaOH	9-NH4Cl	10-DI H2O	11-Other*	1	3	1	1
										Number of Containers per Sample:		1	1	1	1

Laboratory Use Only
Cooler Present: Y
Seals Intact: NA
Cooler Temperature: 5.3 °C Ice IR#3 9/13/17 F30

Sampled by: Briley Morrill
Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
Briley Morrill (AECOM) 09/13/17 0705	JCS 9/13/17 715	JCS 9/13/17 F30	9/13/17 0903
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)

CERTIFICATE OF ANALYSIS

Mark Owen
AECOM Environment - ENSR
9 Jonathon Bourne Dr.
Pocasset, MA 02559

RE: Orleans MA (60476644.11.1.B.2.A)
ESS Laboratory Work Order Number: 1709331

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 12:59 pm, Sep 27, 2017

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1709331

SAMPLE RECEIPT

The following samples were received on September 13, 2017 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
1709331-01	MW-B2010C	Ground Water	200.7, 350.1, 353.2, 4500N, 5310B, 9038, 9250
1709331-02	MW-B2020B	Ground Water	200.7, 350.1, 353.2, 4500N, 5310B, 9038, 9250
1709331-03	MW-B2020C	Ground Water	200.7, 350.1, 353.2, 4500N, 5310B, 9038, 9250
1709331-04	MW-B2050A	Ground Water	350.1, 353.2, 4500N, 5310B, 9038, 9250
1709331-05	MW-B2050B	Ground Water	350.1, 353.2, 4500N, 5310B, 9038, 9250
1709331-06	MW-B2050C	Ground Water	350.1, 353.2, 4500N, 5310B, 9038, 9250
1709331-07	MW-BC2C	Ground Water	350.1, 353.2, 4500N, 5310B, 9038, 9250
1709331-08	MW-BC3B	Ground Water	350.1, 353.2, 4500N, 5310B, 9038, 9250
1709331-09	MW-B1075B	Ground Water	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: 1709331

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

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Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1709331

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH / 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-B2010C
Date Sampled: 09/13/17 13:50
Percent Solids: N/A

ESS Laboratory Work Order: 1709331
ESS Laboratory Sample ID: 1709331-01
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**46.2** (0.100)		200.7		1	KJK	09/14/17 23:02	10	10	CI71436
Manganese	**2.56** (0.020)		200.7		1	KJK	09/14/17 23:02	10	10	CI71436

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B2010C
Date Sampled: 09/13/17 13:50
Percent Solids: N/A

ESS Laboratory Work Order: 1709331
ESS Laboratory Sample ID: 1709331-01
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	ND (0.10)		350.1		1	JLK	09/18/17 18:45	mg/L	CI71804
Chloride	**37.4** (3.0)		9250		1	EEM	09/18/17 11:52	mg/L	CI71806
Dissolved Organic Carbon (Average)	**69.4** (5.00)		5310B		10	DEL	09/16/17 14:33	mg/L	[CALC]
Nitrate as N	**0.182** (0.030)		353.2		1	JLK	09/14/17 21:25	mg/L	[CALC]
Nitrite as N	**0.081** (0.010)		353.2		1	JLK	09/14/17 20:47	mg/L	CI71446
Sulfate	**73.5** (25.0)		9038		5	JLK	09/19/17 17:05	mg/L	CI71943
Total Nitrogen	**2.26** (0.220)		4500N		1	EEM	09/18/17 16:34	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B2020B
Date Sampled: 09/13/17 13:00
Percent Solids: N/A

ESS Laboratory Work Order: 1709331
ESS Laboratory Sample ID: 1709331-02
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	ND (0.100)		200.7		1	KJK	09/14/17 23:06	10	10	CI71436
Manganese	**0.187** (0.020)		200.7		1	KJK	09/14/17 23:06	10	10	CI71436

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B2020B
Date Sampled: 09/13/17 13:00
Percent Solids: N/A

ESS Laboratory Work Order: 1709331
ESS Laboratory Sample ID: 1709331-02
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	09/18/17 18:45	mg/L	CI71804
Chloride	**38.0** (3.0)		9250		1	EEM	09/18/17 11:53	mg/L	CI71806
Dissolved Organic Carbon (Average)	**29.8** (2.50)		5310B		5	DEL	09/16/17 15:36	mg/L	[CALC]
Nitrate as N	**5.96** (0.220)		353.2		10	JLK	09/14/17 21:46	mg/L	[CALC]
Nitrite as N	**0.540** (0.020)		353.2		2	JLK	09/14/17 21:08	mg/L	CI71446
Sulfate	**29.7** (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71943
Total Nitrogen	**7.84** (0.400)		4500N		10	EEM	09/18/17 16:35	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B2020C
Date Sampled: 09/13/17 13:25
Percent Solids: N/A

ESS Laboratory Work Order: 1709331
ESS Laboratory Sample ID: 1709331-03
Sample Matrix: Ground Water
Units: mg/L

Extraction Method: 200.7/6010BNoDigest
All methods used are in accordance with 40 CFR 136.

Dissolved Metals

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	I/V	F/V	Batch
Iron	**13.1** (0.100)		200.7		1	KJK	09/14/17 23:23	10	10	CI71436
Manganese	**2.08** (0.020)		200.7		1	KJK	09/14/17 23:23	10	10	CI71436

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B2020C
Date Sampled: 09/13/17 13:25
Percent Solids: N/A

ESS Laboratory Work Order: 1709331
ESS Laboratory Sample ID: 1709331-03
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	ND (0.10)		350.1		1	JLK	09/18/17 18:46	mg/L	CI71804
Chloride	**31.2** (3.0)		9250		1	EEM	09/18/17 11:54	mg/L	CI71806
Dissolved Organic Carbon (Average)	**14.2** (1.00)		5310B		2	DEL	09/16/17 15:50	mg/L	[CALC]
Nitrate as N	ND (0.030)		353.2		1	JLK	09/14/17 21:28	mg/L	[CALC]
Nitrite as N	**0.010** (0.010)		353.2		1	JLK	09/14/17 20:51	mg/L	CI71446
Sulfate	**20.9** (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71943
Total Nitrogen	**0.424** (0.220)		4500N		1	EEM	09/20/17 16:25	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B2050A
Date Sampled: 09/13/17 12:20
Percent Solids: N/A

ESS Laboratory Work Order: 1709331
ESS Laboratory Sample ID: 1709331-04
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	**0.63** (0.10)		350.1		1	JLK	09/18/17 18:47	mg/L	CI71804
Chloride	**65.8** (3.0)		9250		1	EEM	09/18/17 11:55	mg/L	CI71806
Dissolved Organic Carbon (Average)	**5.63** (0.500)		5310B		1	DEL	09/16/17 16:02	mg/L	[CALC]
Nitrate as N	**25.5** (1.01)		353.2		50	JLK	09/14/17 21:47	mg/L	[CALC]
Nitrite as N	**0.166** (0.010)		353.2		1	JLK	09/14/17 20:52	mg/L	CI71446
Sulfate	**5.3** (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71943
Total Nitrogen	**25.6** (1.20)		4500N		50	EEM	09/20/17 16:27	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B2050B
Date Sampled: 09/13/17 11:45
Percent Solids: N/A

ESS Laboratory Work Order: 1709331
ESS Laboratory Sample ID: 1709331-05
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	09/18/17 18:48	mg/L	CI71804
Chloride	**119** (30.0)		9250		10	EEM	09/18/17 12:23	mg/L	CI71806
Dissolved Organic Carbon (Average)	**5.01** (0.500)		5310B		1	DEL	09/16/17 16:14	mg/L	[CALC]
Nitrate as N	**3.94** (0.210)		353.2		10	JLK	09/14/17 21:52	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	09/14/17 20:53	mg/L	CI71446
Sulfate	**8.7** (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71943
Total Nitrogen	**3.94** (0.400)		4500N		10	EEM	09/20/17 16:28	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B2050C
Date Sampled: 09/13/17 11:15
Percent Solids: N/A

ESS Laboratory Work Order: 1709331
ESS Laboratory Sample ID: 1709331-06
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	09/18/17 18:50	mg/L	CI71804
Chloride	**278** (30.0)		9250		10	EEM	09/18/17 12:24	mg/L	CI71806
Dissolved Organic Carbon (Average)	**3.73** (0.500)		5310B		1	DEL	09/16/17 16:52	mg/L	[CALC]
Nitrate as N	**2.19** (0.110)		353.2		5	JLK	09/14/17 21:53	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	09/14/17 20:54	mg/L	CI71446
Sulfate	**8.9** (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71943
Total Nitrogen	**2.53** (0.300)		4500N		5	EEM	09/20/17 16:29	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BC2C
Date Sampled: 09/13/17 09:50
Percent Solids: N/A

ESS Laboratory Work Order: 1709331
ESS Laboratory Sample ID: 1709331-07
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	**0.12** (0.10)		350.1		1	JLK	09/18/17 18:51	mg/L	CI71804
Chloride	**92.5** (30.0)		9250		10	EEM	09/18/17 12:25	mg/L	CI71806
Dissolved Organic Carbon (Average)	**3.32** (0.500)		5310B		1	DEL	09/16/17 17:04	mg/L	[CALC]
Nitrate as N	**3.13** (0.110)		353.2		5	JLK	09/14/17 21:54	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	09/14/17 21:00	mg/L	CI71446
Sulfate	ND (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71943
Total Nitrogen	**3.13** (0.300)		4500N		5	EEM	09/20/17 16:29	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-BC3B
Date Sampled: 09/13/17 09:15
Percent Solids: N/A

ESS Laboratory Work Order: 1709331
ESS Laboratory Sample ID: 1709331-08
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	ND (0.10)		350.1		1	JLK	09/18/17 18:53	mg/L	CI71804
Chloride	**153** (30.0)		9250		10	EEM	09/18/17 12:26	mg/L	CI71806
Dissolved Organic Carbon (Average)	**3.79** (0.500)		5310B		1	DEL	09/16/17 17:16	mg/L	[CALC]
Nitrate as N	**3.45** (0.110)		353.2		5	JLK	09/14/17 21:55	mg/L	[CALC]
Nitrite as N	ND (0.010)		353.2		1	JLK	09/14/17 21:00	mg/L	CI71446
Sulfate	**9.1** (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71943
Total Nitrogen	**3.45** (0.300)		4500N		5	EEM	09/20/17 16:32	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA
Client Sample ID: MW-B1075B
Date Sampled: 09/13/17 10:30
Percent Solids: N/A

ESS Laboratory Work Order: 1709331
ESS Laboratory Sample ID: 1709331-09
Sample Matrix: Ground Water

All methods used are in accordance with 40 CFR 136.

Classical Chemistry

Analyte	Results (MRL)	MDL	Method	Limit	DF	Analyst	Analyzed	Units	Batch
Ammonia as N	**12.2** (1.00)		350.1		10	EEM	09/21/17 15:35	mg/L	CI72035
Chloride	**147** (30.0)		9250		10	EEM	09/18/17 12:27	mg/L	CI71806
Dissolved Organic Carbon (Average)	**9.48** (0.500)		5310B		1	DEL	09/16/17 17:29	mg/L	[CALC]
Nitrate as N	**0.751** (0.030)		353.2		1	JLK	09/14/17 21:39	mg/L	[CALC]
Nitrite as N	**0.064** (0.010)		353.2		1	JLK	09/14/17 21:01	mg/L	CI71446
Sulfate	**26.8** (5.0)		9038		1	JLK	09/19/17 17:05	mg/L	CI71943
Total Nitrogen	**15.1** (2.02)		4500N		10	EEM	09/20/17 16:39	mg/L	[CALC]

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1709331

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Dissolved Metals										
Batch CI71436 - 200.7/6010BNoDigest										
Blank										
Iron	ND	0.100	mg/L							
Manganese	ND	0.020	mg/L							
LCS										
Iron	2.47		mg/L	2.500		99	80-120			
Manganese	0.502		mg/L	0.5000		100	80-120			
Classical Chemistry										
Batch CI71446 - [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	0.268		mg/L	0.2497		107	90-110			
Nitrite as N	0.268		mg/L	0.2497		107	90-110			
Batch CI71447 - [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	0.486		mg/L							
Nitrate/Nitrite as N	0.486		mg/L	0.5000		97	90-110			
Nitrate/Nitrite as N	0.486		mg/L	0.5000		97	90-110			
Total Nitrogen	0.486		mg/L							
Batch CI71530 - 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	14.7	2.00	mg/L	14.20		103	80-120			
Total Nitrogen	14.7	2.00	mg/L							
Batch CI71607 - 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)	4.97	0.500	mg/L	5.000		99	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1709331

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
Classical Chemistry										
Batch CI71607 - General Preparation										
Dissolved Organic Carbon (2)	4.90	0.500	mg/L	5.000		98	80-120			
Dissolved Organic Carbon (Average)	4.93	0.500	mg/L							
LCS Dup										
Dissolved Organic Carbon (1)	5.14	0.500	mg/L	5.000		103	80-120	3	200	
Dissolved Organic Carbon (2)	5.19	0.500	mg/L	5.000		104	80-120	6	200	
Dissolved Organic Carbon (Average)	5.17	0.500	mg/L							
Batch CI71804 - NH4 Prep										
Blank										
Ammonia as N	ND	0.10	mg/L							
LCS										
Ammonia as N	0.11	0.10	mg/L	0.09994		112	80-120			
LCS										
Ammonia as N	1.12	0.10	mg/L	0.9994		112	80-120			
Batch CI71806 - General Preparation										
Blank										
Chloride	ND	3.0	mg/L							
LCS										
Chloride	32.5		mg/L	30.00		108	90-110			
Batch CI71943 - General Preparation										
Blank										
Sulfate	ND	5.0	mg/L							
LCS										
Sulfate	9.4		mg/L	9.988		94	85-115			
Batch CI71949 - 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	15.5	2.00	mg/L	14.20		109	80-120			
Total Nitrogen	15.5	2.00	mg/L							
Batch CI72035 - NH4 Prep										
Blank										
Ammonia as N	ND	0.10	mg/L							
LCS										
Ammonia as N	0.12	0.10	mg/L	0.09994		120	80-120			
LCS										
Ammonia as N	0.92	0.10	mg/L	0.9994		92	80-120			

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1709331

Notes and Definitions

U	Analyte included in the analysis, but not detected
D	Diluted.
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1709331

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

United States Department of Agriculture Soil Permit: P330-12-00139

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB/MM

Shipped/Delivered Via: ESS Courier

ESS Project ID: 1709331
Date Received: 9/13/2017
Project Due Date: 9/20/2017
Days for Project: 5 Day

1. Air bill manifest present? No
   Air No.: NA
2. Were custody seals present? No
3. Is radiation count <100 CPM? Yes
4. Is a Cooler Present? Yes
   Temp: 5.7 Iced with: Ice
5. Was COC signed and dated by client? Yes
6. Does COC match bottles? Yes
7. Is COC complete and correct? Yes
8. Were samples received intact? Yes
9. **Were labs informed about short holds & rushes?** (Yes) / No / NA
10. Were any analyses received outside of hold time? Yes / (No)

11. Any Subcontracting needed? Yes / (No)
    ESS Sample IDs:
    Analysis:
    TAT:
12. Were VOAs received? Yes / (No)
    a. Air bubbles in aqueous VOAs? Yes / (No)
    b. Does methanol cover soil completely? Yes / No / NA

13. Are the samples properly preserved? (Yes) / No
    a. If metals preserved upon receipt: Date: Time: By:
    b. Low Level VOA vials frozen: Date: Time: By:

Sample Receiving Notes:

14. Was there a need to contact Project Manager? Yes / (No)
    a. Was there a need to contact the client? Yes / (No)
    Who was contacted? Date: Time: By:

Sample Number	Container ID	Proper Container	Air Bubbles Present	Sufficient Volume	Container Type	Preservative	Record pH (Cyanide and 608 Pesticides)
01	162890	Yes	NA	Yes	VOA Vial - HCl	HCl	
01	162891	Yes	NA	Yes	VOA Vial - HCl	HCl	
01	162894	Yes	NA	Yes	250 mL Poly - Unpres	NP	
01	162903	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
01	162912	Yes	NA	Yes	500 mL Poly - Unpres	NP	
01	162921	Yes	NA	Yes	250 mL Amber - Unpres	NP	
02	162888	Yes	NA	Yes	VOA Vial - HCl	HCl	
02	162889	Yes	NA	Yes	VOA Vial - HCl	HCl	
02	162893	Yes	NA	Yes	250 mL Poly - Unpres	NP	
02	162902	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
02	162911	Yes	NA	Yes	500 mL Poly - Unpres	NP	
02	162920	Yes	NA	Yes	250 mL Amber - Unpres	NP	
03	162886	Yes	NA	Yes	VOA Vial - HCl	HCl	
03	162887	Yes	NA	Yes	VOA Vial - HCl	HCl	
03	162892	Yes	NA	Yes	250 mL Poly - Unpres	NP	
03	162901	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
03	162910	Yes	NA	Yes	500 mL Poly - Unpres	NP	
03	162919	Yes	NA	Yes	250 mL Amber - Unpres	NP	
04	162884	Yes	NA	Yes	VOA Vial - HCl	HCl	
04	162885	Yes	NA	Yes	VOA Vial - HCl	HCl	
04	162900	Yes	NA	Yes	1L Poly - H2SO4	H2SO4	
04	162909	Yes	NA	Yes	500 mL Poly - Unpres	NP	
04	162918	Yes	NA	Yes	250 mL Amber - Unpres	NP	
05	162882	Yes	NA	Yes	VOA Vial - HCl	HCl	

ESS Laboratory Sample and Cooler Receipt Checklist

Client: AECOM Environment - ENSR - KPB/MM

ESS Project ID: 1709331

Date Received: 9/13/2017

05	162883	Yes	NA	Yes	VOA Vial - HCl	HCl
05	162899	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
05	162908	Yes	NA	Yes	500 mL Poly - Unpres	NP
05	162917	Yes	NA	Yes	250 mL Amber - Unpres	NP
06	162880	Yes	NA	Yes	VOA Vial - HCl	HCl
06	162881	Yes	NA	Yes	VOA Vial - HCl	HCl
06	162898	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
06	162907	Yes	NA	Yes	500 mL Poly - Unpres	NP
06	162916	Yes	NA	Yes	250 mL Amber - Unpres	NP
07	162878	Yes	NA	Yes	VOA Vial - HCl	HCl
07	162879	Yes	NA	Yes	VOA Vial - HCl	HCl
07	162897	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
07	162906	Yes	NA	Yes	500 mL Poly - Unpres	NP
07	162915	Yes	NA	Yes	250 mL Amber - Unpres	NP
08	162876	Yes	NA	Yes	VOA Vial - HCl	HCl
08	162877	Yes	NA	Yes	VOA Vial - HCl	HCl
08	162896	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
08	162905	Yes	NA	Yes	500 mL Poly - Unpres	NP
08	162914	Yes	NA	Yes	250 mL Amber - Unpres	NP
09	162874	Yes	NA	Yes	VOA Vial - HCl	HCl
09	162875	Yes	NA	Yes	VOA Vial - HCl	HCl
09	162895	Yes	NA	Yes	1L Poly - H2SO4	H2SO4
09	162904	Yes	NA	Yes	500 mL Poly - Unpres	NP
09	162913	Yes	NA	Yes	250 mL Amber - Unpres	NP

2nd Review

Are barcode labels on correct containers? (Yes) / No

Completed By: _____ Date & Time: 9/13/17 1940

Reviewed By: _____ Date & Time: 9/13/17 1942

Delivered By: _____ 9/13/17 1942

ESS Laboratory

Division of Thielsch Engineering, Inc.
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CHAIN OF CUSTODY

ESS Lab # 1709331

Turn Time 5-Day Rush

Regulatory State

Is this project for any of the following?: ○CT RCP ○MA MCP ○RGP

Reporting Limits

Electonic Deliverables ☐Limit Checker ☐Standard Excel ☐Other (Please Specify →)

Company Name	Project #	Project Name
AECOM	60471644.11.1.B.2.A	Orleans PRB Quarterly

Contact Person	Address
Julianne Marion	250 Apollo Drive

City	State	Zip Code	PO #
Chelmsford	MA	01824	

Telephone Number	FAX Number	Email Address
905-905-2419		Julianne.marion@aecom.com

ESS Lab ID	Collection Date	Collection Time	Sample Type	Sample Matrix	Sample ID	Analysis: NO2, NO3, TN, SO4, Cl	TN, NH4	DOC	DISS(LF) Fe, Mn
1	09/13/17	1350	G	GW	MW-B2010C	X	X	X	X
2	09/13/17	1300	G	GW	MW-B2020B	X	X	X	X
3	09/13/17	1325	G	GW	MW-B2020C	X	X	X	X
4	09/13/17	1220	G	GW	MW-B2050A	X	X	X	
5	09/13/17	1145	G	GW	MW-B2050B	X	X	X	
6	09/13/17	1115	G	GW	MW-B2050C	X	X	X	
7	09/13/17	0950	G	GW	MW-BC2C	X	X	X	
8	09/13/17	0915	G	GW	MW-BC3B	X	X	X	
9	09/13/17	1030	G	GW	MW-B1075B	X	X	X	
	~~09/13/17~~		G	GW	MW-1	X	X	X	Bkm

Container Type:	P	P	AG	P	
Container Volume:	5	6	3	3	
Preservation Code:	1	3	1	1	
Number of Containers per Sample:	1	1	1	1	

Container Type: AC-Air Cassette AG-Amber Glass B-BOD Bottle C-Cubitainer G - Glass O-Other P-Poly S-Sterile V-Vial

Container Volume: 1-100 mL 2-2.5 gal 3-250 mL 4-300 mL 5-500 mL 6-1L 7-VOA 8-2 oz 9-4 oz 10-8 oz 11-Other*

Preservation Code: 1-Non Preserved 2-HCl 3-H2SO4 4-HNO3 5-NaOH 6-Methanol 7-Na2S2O3 8-ZnAce, NaOH 9-NH4Cl 10-DI H2O 11-Other*

Laboratory Use Only

Cooler Present: Yes

Seals Intact: NA

Cooler Temperature: 5.7 °C I.R. 17.03 9/13/17 1910

Sampled by: Briley Morrill

Comments: Please specify "Other" preservative and containers types in this space

Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)
Briley Morrill (AECOM) 09/13/17 1536	9/13/17 1715	9/13/17 1900	9/13/17 1917
Relinquished by: (Signature, Date & Time)	Received By: (Signature, Date & Time)	Relinquished By: (Signature, Date & Time)	Received By: (Signature, Date & Time)