ESTCP

FINAL REPORT

Evaluation of a Sustainable and Passive Approach to Treat Large, Dilute Chlorinated VOC Groundwater Plumes

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14. ABSTRACT

The overall objective of this project was to demonstrate effective in situ biological treatment of large, dilute cVOC plumes using an approach that is both sustainable and cost effective. The critical objectives of this demonstration were to determine whether an off-the-grid biosparging system could sustainably and economically deliver gaseous amendments in a biobarrier configuration across a large, dilute plume, stimulating indigenous bacteria to biodegrade target cVOCs, and whether consistent in situ treatment of these cVOCs to target levels (i.e., MCLs) was feasible.

During this project, an oxygen and alkane gas (propane) with gaseous nutrient (ammonia) cometabolic biosparging system in a barrier configuration was successfully utilized to degrade cVOCs (e.g., cis-DCE and VC) in a large, dilute groundwater plume. This cometabolic bioremediation effort demonstrated that low, yet still above MCLs, cVOC concentrations in large plumes can be sustainably and cost effectively treated for cases when attenuation processes themselves are insufficient to protect receptors.

Application of the improved methods for the contaminant treatment demonstrated during this project may result in significant cost savings for the DoD when reduction of cVOCs in a large, dilute groundwater plume is a significant driver of remediation costs.

15. SUBJECT TERMS

Cometabolism, cVOC, large dilute plume, bioremediation, cometabolic biosparging, aerobic, sparge testing, TCE, cis-DCE, vinyl chloride, sustainable, solar

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ACRONYMS AND ABBREVIATIONS

µg	micrograms
AFB	Air Force Base
AFCEC	Air Force Civil Engineer Center
Ah	Ampere hour
AMO	ammonia monooxygenase
APTIM	Aptim Federal Services, LLC
AS	air sparging
BAA	broad agency announcement
bgs	below ground surface
BMW	background monitoring well
BRAC	Base Realignment and Closure
CB&I	Chicago Bridge and Iron
cis-DCE	*cis*-1,2-Dichloroethene
COC	contaminants of concern or chain of custody
cu	cubic feet
cVOC	chlorinated volatile organic compound
1,4-D	1,4-dioxane
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
DC	direct current
DoD	United States Department of Defense
EC	electric conductivity
ESTCP	Environmental Security Technology Certification Program
EtnC	ethene monooxygenase
EtnE	epoxyalkane transferase
FAA	Federal Aviation Administration
ID	inner diameter
IRP	Installation Restoration Program
ISCO	*in situ* chemical oxidation
ISCR	*in situ* chemical reduction
DAP	diammonium phosphate
DC	direct current
DO	dissolved oxygen
DoD	United States Department of Defense
EC	electric conductivity

EDB	1,2-dibromoethane
ERD	enhanced reductive dechlorination
ESTCP	Environmental Security Technology Certification Program
EVO	emulsified vegetable oil
ft	foot or feet
GAC	granular activated carbon
HCl	hydrochloric acid
HPT	Hydraulic Profiling Tool boring
HPT-GW	Hydraulic Profiling Tool Groundwater Sampler
H_2SO_4	sulfuric acid
ID	inner diameter
IDW	investigation derived waste
IRP	Installation Restoration Program
ISCO	in situ chemical oxidation
ISCR	in situ chemical reduction
L	liter(s)
lbs	pounds
LEL	lower explosive limit
LTM	long-term monitoring
MBAFB	Myrtle Beach Air Force Base
MCL	Maximum Contaminant Level
MNA	monitored natural attenuation
mg	milligram(s)
min	minute
mL	milliliter(s)
MTBE	methyl tertiary-butyl ether
mV	millivolt
N	Nitrogen
NAS	Naval Air Station
NDMA	*N*-Nitrosodimethylamine
Ng	nanogram(s)
N_2O	nitrous oxide
NPV	net present value
OD	outer diameter
O&M	operation and maintenance
ORP	oxidation-reduction potential
P	phosphorus

P&ID	piping and instrumentation diagram
P&T	pump and treat
PCE	perchloroethene
PID	photoionization detector
PLC	programmable logic controller
PMMO	particulate methane monooxygenase
PMW	performance monitoring well
PPE	personal protective equipment
PPO	propane monooxygenase
ppmv	parts per million by volume
PQL	practical quantitation limit
PRB	permeable reactive barrier
P&T	pump and treat
PVC	polyvinyl chloride

QC	quality control
qPCR	quantitative polymerase chain reaction

RDO	rugged dissolved oxygen probe
RPM	Remedial Project Manager

SCADA	supervisory control and data acquisition
SCAM	short chain alkane monooxygenase
SCDHEC	South Carolina Department of Health and Environmental Control
SCFM	standard cubic feet per minute
SERDP	Strategic Environmental Research and Development Program
SMMO	soluble methane monooxygenase
SSHP	Site Safety and Health Plan
STW	sparge testing well
SVE	soil vapor extraction
SWMU	Solid Waste Management Unit

TCE	triethyl phosphate
TCP	1,2,3-trichloropropane
TEP	trichloroethene
TOC	total organic carbon

UIC	Underground Injection Control
USEPA/EPA	United States Environmental Protection Agency

V	volt
VC	vinyl chloride
VOA	volatile organic analysis (vials)
VOC	volatile organic compound
VP	vapor probe

ZVI	zero-valent iron

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We wish to thank the USAF/AFCEC and Myrtle Beach Airport environmental staff involved with the former Myrtle Beach Air Force Base site for their support during this demonstration. In particular, a special thanks to Ms. Catherine Jerrard with USAF/AFCEC-BRAC for her dedication to the project and its success, as well as Mr. Ryan Betcher who assisted with logistics and approvals at the airport. We also wish to thank ESTCP for their financial support, and Dr. Andrea Leeson, the Environmental Restoration Program Manager at ESTCP, for her guidance. We would also like to acknowledge and thank Mr. James Begley from MT Environmental Restoration for his assistance with gas delivery design, Mr. Jeff Leaver for his hard work with system installation, monitoring and O&M, and the capable staff at APTIM that conducted all the numerous technical, laboratory, and field tasks associated with this successful project. In particular, Brian McInturff, Tarek Ladaa, Dr. Paul Koster van Groos, Sheryl Streger, Rachael Rezes, Paul Hedman, Antonio Soto, and Matthew Mikulin of APTIM were vital to project success. Their efforts ultimately lead to the quality experimental results and findings demonstrated during this project.

ABSTRACT

One of the greatest challenges remaining for remediating chlorinated volatile organic compounds (cVOCs) at DoD sites is the treatment and/or control of large, dilute plumes. Current approaches to address this challenge are typically long-term and have high capital, operation, and maintenance costs. Cometabolism is showing significant promise in this area because organisms grow aerobically on a supplied substrate (e.g., propane or methane) rather than the trace contaminant, allowing good degradation kinetics, minimal impacts to aquifer geochemistry, and the ability to achieve part-per-trillion contaminant concentrations. The key objective of this ESTCP-funded project was to demonstrate effective *in situ* co-metabolic treatment of a large, dilute CVOC plume using an approach that is both environmentally sustainable and cost effective.

This project entailed cometabolic biosparging using a line of sparge wells installed perpendicular to groundwater flow across the width of a large, dilute CVOC plume downgradient of Building 324 at the former Myrtle Beach Air Force Base in SC. The 210-foot-wide groundwater plume, with *cis*-DCE and vinyl chloride concentrations in excess of federal MCLs, was successfully treated as it flowed through a biologically active zone (i.e., biobarrier) created by sparging oxygen, an alkane gaseous substrate (propane), and a gaseous nutrient (ammonia). The biosparging system, process controls, and system monitoring equipment were powered by an off-the-grid solar energy system. Oxygen, propane, and ammonia were stored on site in cylinders, and configured to provide the appropriate delivery pressures and flows.

Laboratory treatability studies performed with aquifer materials indicated that propane was the most effective cometabolic substrate for this site, and that nutrient addition would be required for effective treatment. Due to the vertical anisotropy of the aquifer observed during site characterization activities, the biosparging system design included 22 sparge wells screened across three vertical depth intervals to effectively distribute gaseous amendments. Sparging of the gases was performed at a single well at a time, to minimize instantaneous flows required.

An extensive monitoring network, consisting of 27 monitoring wells, 6 vapor probes, and 4 dedicated dissolved oxygen probes were installed, and construction of the biosparging system was completed in mid-July of 2019. Startup of the biosparging system occurred in late July, with oxygen-only sparging cycles being performed for several weeks to establish aerobic conditions within the aquifer. Propane and ammonia sparging cycles began in late September 2019, and continued until September 2020. Upon completion of system optimization, significant decreases in both *cis*-DCE and vinyl chloride groundwater concentrations were observed at the monitoring wells located within and downgradient of the biobarrier, with concentrations in most of the downgradient wells consistently measuring below MCLs.

In summary, the data from this ESTCP field test clearly show that propane, ammonia, and oxygen biosparging can be an effective approach to reduce and maintain concentrations of cVOCs, such as *cis*-DCE and VC, below relevant MCLs. The off-the-grid solar powered biosparging system proved to be highly reliable, simple to operate and maintain, and economical for dilute plume treatment. For many large, dilute plume applications, this type of biosparging system is expected to be significantly less expensive to install and operate than a conventional P&T system or other in situ approaches, such as a ZVI barrier for groundwater treatment.

EXECUTIVE SUMMARY

INTRODUCTION

Chlorinated volatile organic compounds (cVOCs) continue to be primary contaminants of concern for the US Department of Defense (DoD), even though many suitable treatment technologies have been developed and verified. One of the greatest challenges remaining for remediating these contaminants at DoD sites and protecting downgradient receptors is the treatment and/or control of large, dilute plumes. Remedial costs are particularly high at sites where contamination is extensive, but concentrations are low. Current approaches to address large, dilute cVOC plumes are typically long-term and have high capital and operation and maintenance (O&M) costs.

Achieving clean-up levels for cVOCs and other organic pollutants in plumes that have low part-per-billion [i.e., micrograms per liter (µg/L)] concentrations is a difficult technological challenge. Cometabolism has shown significant promise in this area because organisms grow aerobically on a supplied substrate (e.g., propane or methane) rather than the trace contaminant, allowing good degradation kinetics, minimal impacts to aquifer geochemistry, and the ability to achieve nanogram per liter (ng/L) contaminant concentrations. However, to meet current DoD needs for large, dilute cVOC plumes, this technology must be efficient, sustainable, and cost effective. The development and field validation of an off-the-grid biosparging system capable of meeting these needs was the key goal of this field demonstration.

OBJECTIVES

The overall objective of this project was to demonstrate effective *in situ* biological treatment of large, dilute cVOC plumes using an approach that is both sustainable and cost effective. The critical objectives of this demonstration were to determine whether an off-the-grid biosparging system could sustainably and economically deliver gaseous amendments in a biobarrier configuration across a large, dilute plume, stimulating indigenous bacteria to biodegrade target cVOCs, and whether consistent *in situ* treatment of these cVOCs to target levels (i.e., MCLs) was feasible.

Specific objectives of this project were as follows:

- Evaluate horizontal and vertical distribution of gaseous amendments within and downgradient of the target treatment zone (e.g., biobarrier) using clustered monitoring wells with short (3 ft) screen intervals installed throughout the vertical treatment zone;
- Monitor oxygen and alkane gas utilization within the biobarrier to optimize gaseous amendment delivery mass and frequencies;
- Quantify changes in concentrations of target cVOCs within and downgradient of the treatment zone during the system operational period;
- Estimate degradation rates of target cVOCs within the treatment zone during active treatment; and
- Determine the efficiency and reliability of a solar powered passive delivery system to provide sufficient gaseous amendments for biosparging on a large scale.

TECHNOLOGY DESCRIPTION

Cometabolic biodegradation typically occurs when one or more broad-specificity oxygenase enzymes are induced in bacteria - enzymes that allow such bacteria to grow on a primary substrate (e.g., methane, propane, butane, isobutene), yet also to biodegrade a range of other non-growth compounds, including many DoD contaminants of concern. The application of this approach for remediation typically entails the addition of a specific growth substrate (often an alkane gas) and oxygen to an aquifer with or without accompanying inorganic nutrients and bioaugmentation cultures. Cometabolic treatment can be applied *in situ* using a number of different configurations based on site conditions, including biosparging, groundwater recirculation with active gas addition and passive gas addition in groundwater wells. Biosparging was used during this demonstration.

There are multiple reasons that cometabolic treatment should be considered at DoD sites, including the following: (1) the approach is widely applicable for groundwater cVOCs (perchloroethene [PCE] excluded) and anaerobic degradation intermediates (e.g., *cis*-1,2-dichloroethene (*cis*-DCE) and vinyl chloride (VC)), as well as a wide range of other DoD contaminants of concern including 1,4-Dioxane (1,4-D), methyl tertiary-butyl ether (MTBE), *N*-Nitrosodimethylamine (NDMA), 1,2-Dibromoethane (EDB), and 1,2,3-trichloropropane (TCP); (2) the technology is very well suited for dilute plumes because the cometabolic organisms are not required to grow on the contaminant of concern, but rather utilize the substrate gas that is supplied to the aquifer; (3) very low treatment levels (e.g., low ng/L concentrations) can be achieved for some pollutants; and (4) groundwater remains aerobic, minimizing issues such as mobilization of metals (e.g., iron, arsenic and manganese), production of hydrogen sulfide, and large shifts in pH, as sometimes observed when high substrate concentrations are added to aquifers for anaerobic treatment of cVOCs and other contaminants.

During this *in situ* demonstration, propane, ammonia and oxygen were added to groundwater via sparging to stimulate native propanotrophs to biodegrade *cis*-DCE and VC *in situ*. The demonstration was performed at the Building 324 plume at former Myrtle Beach Air Force Base (MBAFB). The Building 324 location (Site) had many characteristics that made it ideal for this demonstration, including site accessibility, the presence of a large, dilute cVOC plume (~210 ft wide) with reasonable depth (~35 ft) and thickness (~15 ft) of the target treatment interval, a permeable aquifer that was amenable to sparging, significant historical cVOC concentration data, and existing monitoring wells.

PERFORMANCE ASSESSMENT

Treatment of cis-DCE and VC

The primary objective of this demonstration was to assess the long-term effectiveness of applying aerobic cometabolism to treat low concentrations of *cis*-DCE and VC across the width of the plume. This objective was met. Significant decreases in *cis*-DCE and VC were observed starting approximately 2.5 to 3 months after initiating propane and ammonia biosparging, after sufficient biomass growth had occurred within the aquifer. Decreases in *cis*-DCE concentrations were observed in 20 of the 22 impacted wells located within and downgradient of the biobarrier, with concentrations at all 22 wells consistently below the MCL of 70 µg/L between days 181 and 422 of the demonstration. The estimated decline in the mass flux of *cis*-DCE was ~ 70-fold due to barrier operation from day 294 to the end of the study. Similarly, VC concentrations were below the MCL of 2 µg/L at 15 of the 18 impacted wells by day 294 and remained low for the remainder of the field demonstration.

Much like *cis*-DCE, appreciable decreases in the mass flux of VC were observed starting at day 218 and continuing throughout the course of the field demonstration. VC concentrations remained below the MCL at 16 of the 18 wells during the final performance sampling event conducted on day 422.

The average *cis*-DCE and VC concentrations measured at wells located 25 ft downgradient of the sparge wells during baseline sampling (day -5) and the final performance monitoring event (day 422) showed a 98% and a 92% decrease, respectively. *cis*-DCE and VC generally returned to near baseline concentrations (or in the case of VC, higher than baseline) within 105 days after system shutdown due to the absence of oxygen and cometabolic substrate addition (and possibly nutrient addition), as the degradative activity of the propane oxidizing bacteria (or other bacteria capable of aerobically degrading VC) that were grown within the treatment zone ceased, and contaminated groundwater flowing through this area was no longer being treated.

Maintaining Aerobic Conditions

Achieving and maintaining aerobic conditions within the treatment zone was critical during the demonstration, as cometabolism using an alkane/gas substrate is an aerobic process. This was particularly important at the study site which was anoxic and mildly reducing as the beginning of the study (dissolved oxygen (DO) < 1 mg/L; oxidation-reduction potential (ORP) < -80 mV). DO concentrations above the 3 mg/L target were observed in most of monitoring wells located within the biobarrier throughout the demonstration. Although a few wells (PMW-2I and PMW-3D) were not significantly impacted by oxygen sparging, likely due to aquifer heterogeneity and high oxygen demand (both mineral and biological) in the aquifer, the objective of obtaining and maintaining bulk aerobic conditions in the aquifer was achieved.

Optimizing Propane Delivery

Optimization of propane amendment (mass and sparge frequency) was required to supply enough substrate for biological growth, while ensuring that high dissolved propane concentrations did not lead to continuous competitive inhibition and limit cVOC biodegradation rates. Dissolved propane was measured above 100 µg/L consistently at multiple wells within the biobarrier during Phase 2 of the demonstration. The data showed that propane concentrations were generally higher during the first 2.5 months of Phase 2 operation (with concentrations measured more than 2 mg/L in several wells) and decreased significantly thereafter as biodegradation rates increased. Propane fluxes at the site were high early in the study and decreased approximately ten-fold thereafter due to increased biological activity. Propane oxidizing genes were noted to increase by ~1000x between day 50 and day 294 of sparging operations. The data showed that a propane sparging frequency of approximately once every 1 to 2 weeks (with average mass loading of ~1.5 lbs./day) was optimal in maintaining biological growth/activity without leading to continuous competitive inhibition.

Sparge System Reliability

Reliability of biosparging system operation was an important performance objective, as the regular injection of gaseous amendments is critical to the treatment effectiveness of any cometabolic approach. Additionally, reliable performance minimizes system operating costs. The off-the grid solar power system provided consistent power to the biosparging system throughout the entire 518 days of the demonstration and only required changes to the angles of the solar panel arrays 2 times, with each of these changes accomplished in less than 1 hour. The system operated as designed, and there were no major system or equipment failures during the demonstration.

Ease of Use

System O&M requirements, which primarily consisted of regular system checks and changeout of the oxygen cylinders, were not significant during the demonstration. System checks (which entailed collecting manual system pressure and flow data, performing regular system maintenance, and performing leak checks) were generally performed every 2-3 weeks in under 3 hours per visit. Change out of the oxygen 16-packs was conducted approximately every 2-3 months and was typically performed in under 4 hours. The 6 tanks of liquified propane and 4 tanks of liquified ammonia did not require replacement during 12 months of Phase 2 cometabolic biosparging due to the general efficiency of this treatment approach. The ability to communicate remotely with the system (and adjust gas sparging), as well as programmed logging capabilities of the supervisory control and data acquisition (SCADA) system significantly reduced the number of site visits required. Furthermore, other the groundwater sampling purge water, there was no waste generated during application of this *in situ* technology.

COST ASSESSMENT

The expected cost drivers for installation and operation of a cometabolic biosparging system to treat a full-scale large, dilute cVOC plume, and those that will determine the cost/selection of this technology over other options, include the following:

- Depth of the plume bgs;
- Width, length, and thickness of the plume;
- Aquifer lithology and hydrogeology;
- Passive and sustainable power (solar);
- Length of time for clean-up (e.g., necessity for accelerated clean-up);
- The presence of indigenous bacteria capable of cometabolically degrading cVOCs;
- Concentrations of contaminants and alternate electron acceptors; and
- Presence of co-contaminants.

A cost analysis of a cometabolic biosparging system and two traditional cVOC groundwater treatment approaches to treat a full-scale large, dilute cVOC plume was performed. Cost estimates for full-scale application were developed for the following technologies:

1. Cometabolic biosparging barrier;
2. Passive trench zero valent iron permeable reactive barrier (ZVI PRB); and
3. Pump and treat (P&T).

These three technologies were selected for comparison because they are all typically applied as treatment barriers or for cVOC plume capture. The base case presents a situation where a shallow aquifer, consisting of homogeneous silty sands, is contaminated with trichloroethene (TCE). The contaminated groundwater extends from 10 to 50 ft bgs, along the direction of groundwater flow for 800 ft, and is 400 ft in width. The costing for the template site assumes that the source zone has been treated and that there is no continuing source of groundwater contamination. The cost analyses comparing the above approaches are presented below based on a 30-year operating scenario.

The estimated total costs for the cometabolic biosparge barrier alternative over 30 years are \$3,489,500 with a total NPV of lifetime costs of \$3,616,221. The capital cost including design, work plan, installation of biosparge and monitoring wells, installation of the solar power system, and fabrication, installation, and start-up of the biosparge system is \$445,400. The NPV of the O&M is \$2,177,640 for the 30 years of treatment. The O&M costs primarily include the labor and material costs associated with weekly inspections and battery replacement every five years. The costs for materials and other consumables are negligible with this alternative. The NPV of the 30 years of monitoring and reporting costs is \$993,181.

This alternative ranks lowest in estimated total remedy cost and lowest in NPV of lifetime costs. The estimated capital cost for this approach is the lowest of the three alternatives because of the limited infrastructure required and the relative ease of installation. The estimated long-term O&M costs are also the lowest of the three alternatives, which helps make this the least expensive of the alternatives. As with the other alternatives, total remedy costs will increase if the treatment needs to extend beyond 30 years.

SUMMARY

In summary, the data from this ESTCP field test clearly show that propane, ammonia and oxygen biosparging can be an effective approach to reduce and maintain concentrations of cVOCs, such as *cis*-DCE and VC, below relevant MCLs. The off-the-grid solar powered biosparging system proved to be highly reliable, simple to operate and maintain, and economical for dilute plume treatment. For many large, dilute plume applications, this type of biosparging system is expected to be significantly less expensive to install and operate than a conventional P&T system or other in situ approaches, such as a ZVI barrier for groundwater treatment.

1.0 INTRODUCTION

1.1 BACKGROUND

Chlorinated volatile organic compounds (cVOCs) continue to be primary contaminants of concern for the US Department of Defense (DoD), even though many suitable treatment technologies have been developed and verified. One of the greatest challenges remaining for remediating these contaminants at DoD sites and protecting downgradient receptors is the treatment and/or control of large, dilute plumes. Remedial costs are particularly high at sites where contamination is extensive, but concentrations are low. Current approaches to address large, dilute cVOC plumes are typically long-term and have high capital and operation and maintenance (O&M) costs.

Achieving clean-up levels for cVOCs and other organic pollutants in plumes that have low part-per-billion [i.e., micrograms per liter (µg/L)] concentrations is a difficult technological challenge. Cometabolism has shown significant promise in this area because organisms grow aerobically on a supplied substrate (e.g., propane or methane) rather than the trace contaminant, allowing good degradation kinetics, minimal impacts to aquifer geochemistry, and the ability to achieve nanogram per liter (ng/L) contaminant concentrations (e.g., Fournier et al., 2009, Lippincott et al., 2015; Hatzinger et al., 2011, 2015, 2018). However, to meet current DoD needs, this technology needed to be demonstrated in a sustainable, cost effective manner for treatment of a large, dilute plume. That was the key objective of this field demonstration.

Presently, the most utilized technology for removing cVOCs from groundwater in large, dilute plumes is pump-and-treat (P&T). However, this *ex situ* technology is expensive, requiring the installation of significant infrastructure, including numerous extraction wells and a treatment facility. In addition to high capital costs, annual O&M costs (including groundwater filtration, air strippers and/or granular activated carbon maintenance, and energy) are typically high, and these systems are often operated for decades. Furthermore, treated groundwater typically must either be re-injected into the aquifer (requiring additional wells or infiltration galleries), or sent to a local publicly owned treatment works. The capital cost for installation of pump-and-treat infrastructure and continuing O&M costs for treatment of large volumes of groundwater are anticipated to be prohibitively expensive at some DoD facilities.

In addition to P&T, *in situ* treatment technologies including anaerobic bioremediation (i.e., enhanced reductive dechlorination, or ERD), *in situ* chemical oxidation (ISCO), and *in situ* chemical reduction (ISCR) have been widely and successfully used for treating groundwater contaminated with high concentrations of cVOCs. These approaches, however, are generally ineffective and/or cost prohibitive for treating large, dilute plumes, as further discussed in **Section 2.3.1**.

This project, conducted by Aptim Federal Services, LLC (APTIM), entailed a full-scale demonstration of cometabolic biosparging using a line of vertical biosparging wells installed perpendicular to groundwater flow across the entire width of a large, dilute cVOC plume. As discussed in the Site Selection Memorandum (CB&I, 2017), several sites were evaluated during the site selection process. While some of these sites were determined to be suitable for application of this remedial approach, based on the site selection criteria rating presented in the Memorandum, the Building 324 plume at former Myrtle Beach Air Force Base (MBAFB) was determined to be the most appropriate location for demonstrating this remedial approach.

Remediation of the Building 324 site is being managed by the Air Force Civil Engineer Center (AFCEC) Base Realignment and Closure (BRAC) Division and is identified as Installation Restoration Program (IRP) Site SD019 and SWMU 40. Several other Solid Waste Management Units (SWMUs) are collocated with the site and were being remediated concurrently with SWMU 40. The Building 324 location (Site) had many characteristics that made it ideal for this demonstration, including site accessibility, the presence of a large, dilute cVOC plume (~210 ft wide) with reasonable depth (~35 ft) and thickness (~15 ft) of the target treatment interval, a permeable aquifer that is amenable to sparging, significant historical cVOC concentration data, and existing monitoring wells.

The Building 324 plume contains *cis*-1,2-dichloroethene (*cis*-DCE) and vinyl chloride (VC) above their respective maximum contaminant levels (MCLs) of 70 µg/L and 2 µg/L. During this demonstration, contaminated groundwater was treated as it flowed through a biologically active zone (i.e., bio-curtain) created by biosparging oxygen, an alkane gaseous substrate (propane), and a gaseous nutrient (ammonia) that stimulated indigenous bacteria capable of degrading *cis*-DCE and VC to below their respective MCLs. The biosparging system process control and monitoring equipment was designed and constructed to operate completely "off-the-grid" using sustainable solar power energy, and the gases were pulsed into the aquifer using a passive delivery system that worked entirely based on gas pressures (using compressed and liquified gas cylinders).

1.2 OBJECTIVE OF THE DEMONSTRATION

The overall objective of this project was to demonstrate effective *in situ* biological treatment of large, dilute cVOC plumes using an approach that is both sustainable and cost effective. The critical objectives of this demonstration were to determine whether an off-the-grid biosparging system could sustainably and economically deliver gaseous amendments in a biobarrier configuration across a large, dilute plume, stimulating indigenous bacteria to biodegrade target cVOCs, and whether consistent *in situ* treatment of these cVOCs to target levels (i.e., MCLs) was feasible.

Specific objectives of this project were as follows:

- Evaluate horizontal and vertical distribution of gaseous amendments within and downgradient of the target treatment zone (e.g., biobarrier) using clustered monitoring wells with short (3 ft) screen intervals installed throughout the vertical treatment zone;
- Monitor oxygen and alkane gas utilization within the biobarrier to optimize gaseous amendment delivery mass and frequencies;
- Quantify changes in concentrations of target cVOCs within and downgradient of the treatment zone during the system operational period;
- Estimate degradation rates of target cVOCs within the treatment zone during active treatment; and
- Determine the efficiency and reliability of a solar powered passive delivery system to provide sufficient gaseous amendments for biosparging on a large scale.

1.3 REGULATORY DRIVERS

Chlorinated VOCs, including trichloroethene (TCE), *cis*-DCE, and VC continue to be primary contaminants of concern for the DoD. These compounds are known to be carcinogenic or potentially carcinogenic to humans and are regulated in drinking and groundwater by both the U.S. Environmental Protection Agency (USEPA) and the state of South Carolina. While *cis*-DCE and VC are the two contaminants of concern (COCs) above MCLs in the downgradient portion of the Building 324 plume, these compounds are often comingled with TCE (the parent compound), as is the case in the upgradient portion of the plume. Furthermore, all three of these compounds (as well as several other cVOCs) are susceptible to cometabolic biodegradation. Applicable groundwater standards for these cVOCs are provided in **Table 1.1**.

Table 1.1. Applicable Groundwater Standards

Constituents	USEPA MCL (µg/L)
Trichloroethene (TCE)	5
cis-1,2-dichlorethene (DCE)	70
Vinyl Chloride (VC)	2

The Final Decision and Response to Comments document for the Building 324 plume was issued by the USEPA on September 18, 2003 (USEPA, 2003). The Final Decision selected extraction and treatment of contaminated groundwater combined with monitored natural attenuation (MNA) and land use controls as the final remedy. The selected cleanup goals for TCE, *cis*-DCE and VC at the Site are the same as federal MCLs (USEPA, 2009), and are presented in **Table 1.1**. As discussed in **Section 5.2.1.3**, maximum concentrations of *cis*-DCE and VC observed in the demonstration area during site characterization activities were 133 µg/L and 23.5 µg/L, respectively. The measured concentrations are approximately double the MCL for *cis*-DCE (which has a significantly higher MCL than the other cVOCs listed in **Table 1.1**), and an order of magnitude higher than the MCL for VC. TCE was not observed above the MCL in the demonstration area during these activities.

2.0 TECHNOLOGY

2.1 TECHNOLOGY DESCRIPTION

The underlying approach of gas biosparging using primary cometabolic substrates is mature, cost effective, and can be safely applied in several different configurations based on site conditions. The fundamental concepts supporting this field demonstration were (1) the utilization of aerobic cometabolism for *in situ* degradation of an environmental pollutant, and (2) distribution of gases in the subsurface to stimulate pollutant biodegradation. Each of these concepts is supported by extensive laboratory research and, more recently, field testing. The first publications on cometabolic reactions and their potential applications for remediation date to the 1960s (Alexander, 1967), and scientific research was conducted on the cometabolism of many different compounds thereafter (Alexander, 1994 and references therein). The observation that methanotrophic bacteria are capable of dechlorinating TCE and other chlorinated ethenes and ethanes (Oldenhuis et al., 1989) and that this process can be stimulated *in situ* (Wilson and Wilson, 1985) resulted in the initial field testing of cometabolic degradation for chlorinated solvent remediation (Hazen et al., 1994; Semprini and McCarty, 1991). Since this time period, cometabolic degradation of chlorinated solvents by phenol- and toluene-degrading bacteria has been examined in the field (Hopkins and McCarty, 1995; McCarty et al., 1998), as has the application of propane-oxidizing bacteria for *in situ* treatment of chlorinated solvents (Battelle, 2001; Tovanabootr et al., 2001) and gasoline oxygenates (Steffan et al., 2003).

2.2 TECHNOLOGY DEVELOPMENT

More recent successful field applications of cometabolism have centered around the treatment of several DoD emerging contaminants, including 1,2-dibromoethane (EDB), N-nitrosodimethylamine (NDMA), and 1,4-dioxane (1,4-D). One of the key considerations with these contaminants is that they often occur in aquifers at very low concentrations (e.g., low µg/L range), but still require treatment to meet state or federal regulations that can be in the ng/L range. Cometabolism has proven to be one of the only viable *in situ* technologies to meet these objectives. Most recently, the Environmental Security Technology Certification Program (ESTCP) funded a field demonstration for cometabolic treatment of NDMA (ER-200828; *Field Demonstration of Propane Biosparging for In Situ Remediation of NDMA in Groundwater*) at the Aerojet facility in Rancho Cordova, CA (Hatzinger and Lippincott, 2019), and the AFCEC funded field demonstrations for cometabolic treatment of 1,4-D (BAA Project 518; *Remediation of 1,4-Dioxane Contaminated Aquifers*) at Vandenberg Air Force Base (AFB) in California (Lippincott et al., 2015), and EDB (BAA Project 576; *Enhanced In Situ Bioremediation of EDB at Joint Base Cape Cod*) at Joint Base Cape Cod, MA (Hatzinger et al., 2015, 2018). Each of these field demonstrations showed that target contaminants could be treated *in situ* to below relevant cleanup or health advisory levels using cometabolic remediation. Results from the Vandenberg AFB demonstration, while focused on 1,4-D, also showed that MCLs for several cVOCs (including TCE, *cis*-DCE, 1,1-dichloroethene (1,1-DCE), 1,1-dichloroethane (1,1-DCA) and chloroform) could be attained via cometabolic processes using a biosparging approach at the field scale (**Figure 2.1**). As the general approach of cometabolic biosparging has been successfully field-tested, the results from these demonstrations (and the lessons learned) were utilized during the design of this full-scale field trial.

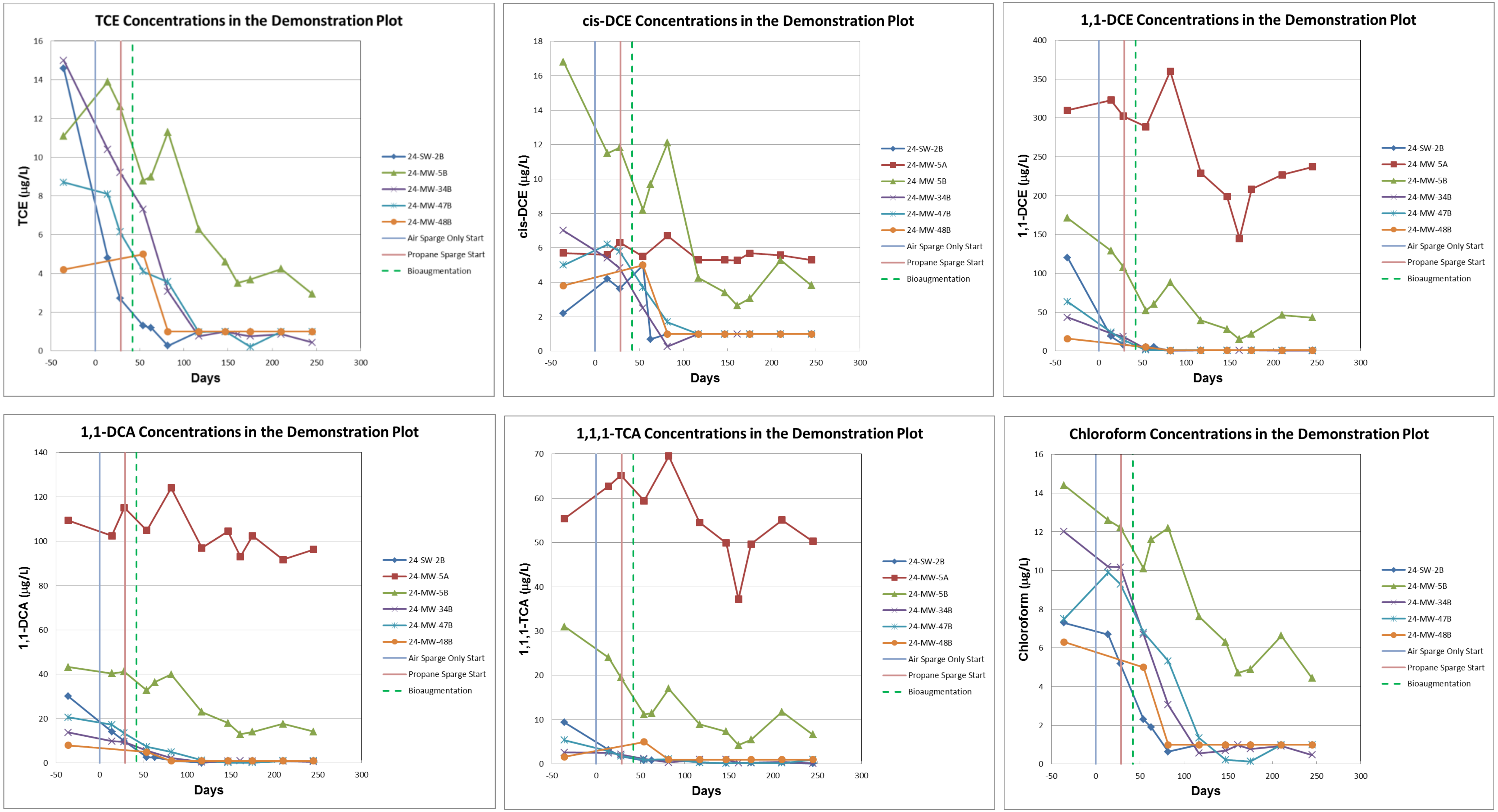

Figure 2.1. Groundwater VOC Concentrations at Vandenberg AFB.

Reductions in groundwater cVOC concentrations observed during an AFCEC-funded field demonstration for co-metabolic treatment of 1,4-D at Vandenberg AFB in California. Well 24-MW-48B was the biosparging well, well 24-MW-5B was located on the outer edge of the treatment zone, and well 24-MW-5A was the control well (screened within a shallower aquifer). TCE and chloroform data for the control well are not shown because concentrations were significantly higher than that of the demonstration wells.

2.3 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY

2.3.1 Advantages

As previously discussed, the most effective and common technology for removing cVOCs from groundwater in large, dilute plumes is P&T. However, this *ex situ* technology is expensive, requiring the installation of significant infrastructure, including numerous extraction wells and a treatment facility. Cometabolic biodegradation of cVOCs has several advantages over the current P&T technology. Importantly, the technology is destructive, and it can be applied *in situ*, thereby reducing the risk of contaminant exposure, reducing contaminant/media disposal costs, and eliminating groundwater recovery costs. Unlike bioremediation processes that require the degradative bacteria to metabolize and grow on the target contaminant, the co-metabolic approach promotes bacterial growth via addition of a co-substrate (i.e., propane), allowing it to degrade the contaminants (cVOCs) to sub-ng/L concentrations. Such low treatment levels are typically not attainable with metabolic systems because there is insufficient carbon and energy for growth at low contaminant concentrations (Alexander, 1994; Schmidt et al., 1985). Furthermore, the cometabolic technology is very flexible and can be applied in a wide range of configurations (source area treatment, *in situ* permeable barriers, re-circulation systems, etc.), and it relies on the use of low-cost substrates (i.e., propane, methane, etc.). It also may allow the simultaneous treatment of multiple co-contaminants (chlorinated ethenes, chlorinated ethanes, NDMA; Tovanabootr et al., 2001; Battelle, 2001, and 1,4-D; Lippincott et al., 2015), without the need for treatment trains and without significantly impacting aquifer geochemistry.

In addition to P&T, *in situ* treatment technologies including anaerobic bioremediation (i.e., ERD), ISCO, and ISCR have been widely and successfully used for treating groundwater contaminated with high concentrations of cVOCs. These approaches, however, are often ineffective and/or cost prohibitive for treating large, dilute plumes. ERD is problematic because substrate must be applied over large areas and cVOC concentrations may be too low to support the growth of *Dehalococcoides* spp. and other dechlorinating bacteria. Moreover, application of this technology often requires a drastic modification of groundwater geochemistry, such as converting an aerobic aquifer to highly anaerobic conditions. This remediation approach results in a variety of secondary groundwater issues, including mobilization of iron, manganese, and/or arsenic, production of sulfide and methane, and elevated total organic carbon (TOC). These changes are often acceptable in a source area which is heavily impacted by cVOCs, but less so in a large, dilute plume where the groundwater resources are more likely to be part of a drinking water aquifer. ERD using emulsified vegetable oil (EVO) or mulch permeable reactive barriers (PRBs) have shown to be effective at passively treating cVOCs in groundwater within large, dilute plumes. However, the longevity of these barriers is limited, thus requiring regular replacement or amendment injections (e.g., multiple EVO injections, or addition of soluble carbon to mulch PRBs). Furthermore, high groundwater velocities and/or lack of complete reductive dechlorination can lead to daughter products (VC in particular) not being completely treated before exiting the barrier.

Similarly, ISCO and ISCR require direct contact between the oxidant/reductant and the dissolved contaminant for reaction to occur, are subject to uneven distribution over large areas, and have limited longevity. ISCO is performed by adding a strong oxidant (typically permanganate, persulfate, or Fenton's reagent) to the subsurface to oxidize target pollutants. Typically, however, most of the added oxidant actually oxidizes non-target species including natural organic matter and reduced minerals.

This often leads to high dosing requirements, thus making treatment of large plumes using ISCO technically impractical and cost prohibitive. Because ISCO requires direct contact between the oxidant and the dissolved contaminant for oxidation to occur, even modest heterogeneities in the aquifer materials make effective distribution of chemical oxidants and sufficient contact in the subsurface unlikely. Furthermore, chemical oxidants are short-lived in the subsurface, and typically require multiple applications to treat contaminant rebound or influx of upgradient contaminants, thus making them ineffective in a barrier treatment configuration.

ISCR technologies, such as micro-scale or nano-scale zero-valent iron (ZVI) injections, have many of the same shortcomings as ISCO, including limited direct contact with contaminants, uneven distribution, and limited longevity. ISCR using ZVI PRBs have shown to be effective at passively treating cVOCs in groundwater within large, dilute plumes. However, the longevity of the ZVI in the barriers can be limited and/or plugging of the barriers can occur, leading to the need for regular replacement of the PRB at a significant capital cost.

Another treatment technology that is sometimes used to treat large, dilute plumes is Air Sparging (AS). While this technology can be effective at removing target cVOCs, AS systems require significant infrastructure, generally have significant power and O&M costs, and often require soil vapor extraction (SVE) systems to capture fugitive emissions in the vadose zone. Additionally, heterogeneities in the aquifer materials can greatly impact the effectiveness of this technology.

MNA is currently the sole remedy for some of the DoDs large, dilute plumes. However, some of the shortcomings associated with this approach include the uncertainty in cleanup time, prolonged liabilities and life-cycle costs, potential for continued plume migration, limited contribution of biodegradation to the overall plume attenuation due to unfavorable geochemical conditions, lack of natural organic carbon, or lack of required microbial species. Consequently, the remediation of large, dilute plumes remains a significant challenge preventing the DoD from meeting its site remediation goals.

2.3.2 Disadvantages

In addition to its many advantages, the cometabolic technology may have some disadvantages. For example, successful application of the technology requires the presence of indigenous alkane- or alkene-gas oxidizing bacteria that can degrade the target contaminants. At some sites, indigenous bacteria able to degrade target cVOCs may not be abundant and/or may not be able to be successfully stimulated. In these cases, bioaugmentation may be required. Likewise, at some sites (including the demonstration site), achieving and demonstrating adequate distribution of injected gasses (propane, oxygen and ammonia) may be challenged by site hydrogeology. These same conditions, however, would likely also limit the implementation of other *in situ*, and possibly *ex situ* technologies.

Finally, successful application of the technology could be inhibited by the presence of certain co-contaminants. For example, some chlorinated ethenes (i.e., TCE and 1,1-DCE in particular) form epoxides during cometabolic degradation that can kill the microbial populations carrying out the reaction. As a result, high concentrations of co-contaminants at a site may result in poor remedial performance. The potential for such inhibition can be assessed by performing laboratory treatability testing.

3.0 PERFORMANCE OBJECTIVES

Performance objectives are summarized in **Table 3.1**, and details are provided in **Sections 3.1** through **3.5**.

Table 3.1. Performance Objectives

Performance Objective	Data Requirements	Success Criteria	Results
Quantitative Performance Objectives			
Determine treatment effectiveness	Groundwater cVOC concentrations at discrete interval background and performance monitoring wells during baseline, operational and post treatment sampling events	Groundwater concentrations of *cis*-DCE and VC less than their MCLs (70 µg/L and 2 µg/L, respectively) at performance monitoring wells located ~10 ft down-gradient of the row of biosparging wells	• MCLs for *cis*-DCE and VC achieved at most wells, and all wells 25 ft downgradient • 1-2 order of magnitude contaminant reductions • 70-fold decline in *cis*-DCE mass flux • Estimated degradation rates sufficient to achieve MCLs in 20' wide barrier
Maintain aerobic conditions within the treatment zone	Groundwater DO concentration measurements at discrete interval performance monitoring wells during sparging and non-sparging time periods	Consistently maintain groundwater DO concentrations >3 mg/L at monitoring wells located within the biobarrier	• DO consistently > 3 mg/L in biobarrier • ORP consistently > +50 mV in biobarrier • Order of magnitude increase in sulfate concentrations
Optimize alkane gas amendment delivery mass and frequencies	Groundwater dissolved alkane gas concentrations at discrete interval performance monitoring wells during sparging and non-sparging time periods	Dissolved propane distributed in biobarrier without leading to continuous competitive inhibition	• Dissolved propane consistently > 100 µg/L in biobarrier • 1000x increase in propane-oxidizing genes • 10-fold decrease in propane flux
Determine sparge system reliability	System operational logs recorded by a data acquisition system	>90% biosparging system operation as designed	• The solar powered biosparging system proved to be extremely reliable
Qualitative Performance Objectives			
Ease of Use	Feedback from field technician on system O&M and time required	A single field technician able to effectively collect system and groundwater measurements	• The biosparging system proved to be easy to operate and maintain

3.1 DETERMINE TREATMENT EFFECTIVENESS

The primary objective of this demonstration was to assess the long-term effectiveness of applying aerobic cometabolism to treat low concentrations of *cis*-DCE and VC across the width of the plume. This objective was met. Significant decreases in *cis*-DCE and VC were observed starting approximately 2.5 to 3 months after initiating propane and ammonia biosparging, after sufficient biomass growth had occurred within the aquifer. Decreases in *cis*-DCE concentrations were observed in 20 of the 22 impacted wells located within and downgradient of the biobarrier, with concentrations at all 22 wells consistently below the MCL of 70 µg/L between days 181 and 422 of the demonstration.

The estimated decline in the mass flux of *cis*-DCE was ~ 70-fold due to barrier operation from day 294 to the end of the study. Similarly, VC concentrations were below the MCL of 2 µg/L at 15 of the 18 impacted wells by day 294 and remained low for the remainder of the field demonstration. Much like *cis*-DCE, appreciable decreases in the mass flux of VC were observed starting at day 218 and continuing throughout the course of the field demonstration. VC concentrations remained below the MCL at 16 of the 18 wells during the final performance sampling event conducted on day 422.

The average *cis*-DCE and VC concentrations measured at wells located 25 ft downgradient of the sparge wells during baseline sampling (day -5) and the final performance monitoring event (day 422) showed a 98% and a 92% decrease, respectively. *cis*-DCE and VC generally returned to near baseline concentrations (or in the case of VC, higher than baseline) within 105 days after system shutdown due to the absence of oxygen and cometabolic substrate addition (and possibly nutrient addition), as the degradative activity of the propane oxidizing bacteria (or other bacteria capable of aerobically degrading VC) that were grown within the treatment zone ceased, and contaminated groundwater flowing through this area was no longer being treated.

3.2 MAINTAIN AEROBIC CONDITIONS WITHIN THE TREATMENT ZONE

Achieving and maintaining aerobic conditions within the treatment zone was critical during the demonstration, as cometabolism using an alkane/gas substrate is an aerobic process. This was particularly important at the study site which was anoxic and mildly reducing as the beginning of the study (dissolved oxygen (DO) < 1 mg/L; oxidation-reduction potential (ORP) < -80 mV). DO concentrations above the 3 mg/L target were observed in most of monitoring wells located within the biobarrier throughout the demonstration. Similarly, the ORP in the biobarrier was near or greater than +50 mV, and sulfate concentration increased by over an order of magnitude, indicating oxidizing conditions. Although a few wells (PMW-2I and PMW-3D) were not significantly impacted by oxygen sparging, likely due to aquifer heterogeneity and high oxygen demand (both mineral and biological) in the aquifer, the objective of obtaining and maintaining bulk aerobic conditions in the aquifer was achieved.

3.3 OPTIMIZE PROPANE GAS AMENDMENT DELIVERY MASS AND FREQUENCY

Optimization of propane amendment (mass and sparge frequency) was required to supply enough substrate for biological growth, while ensuring that high dissolved propane concentrations did not lead to continuous competitive inhibition and limit cVOC biodegradation rates. Dissolved propane was measured above 100 µg/L consistently at multiple wells within the biobarrier during Phase 2 of the demonstration. The data showed that propane concentrations were generally higher during the first 2.5 months of Phase 2 operation (with concentrations measured more than 2 mg/L in several wells) and decreased significantly thereafter as biodegradation rates increased. Propane fluxes at the site were high early in the study and decreased approximately ten-fold thereafter due to increased biological activity. Propane oxidizing genes were noted to increase by ~1000x between day 50 and day 294 of sparging operations. The data showed that a propane sparging frequency of approximately once every 1 to 2 weeks (with average mass loading of ~1.5 lbs./day) was optimal in maintaining biological growth/activity without leading to continuous competitive inhibition.

3.4 DETERMINE SPARGE SYSTEM RELIABILITY

Reliability of biosparging system operation was an important performance objective, as the regular injection of gaseous amendments is critical to the treatment effectiveness of any cometabolic approach. Additionally, reliable performance minimizes system operating costs. The off-the grid solar power system provided consistent power to the biosparging system throughout the entire 518 days of the demonstration and only required changes to the angles of the solar panel arrays 2 times, with each of these changes accomplished in less than 1 hour. The system operated as designed, and there were no major system or equipment failures during the demonstration. The off-the-grid solar powered biosparging system proved to be highly reliable, simple to operate and maintain, and economical for dilute plume treatment.

3.5 EASE OF USE

System O&M requirements, which primarily consisted of regular system checks and changeout of the oxygen cylinders, were not significant during the demonstration. System checks (which entailed collecting manual system pressure and flow data, performing regular system maintenance, and performing leak checks) were generally performed every 2-3 weeks in under 3 hours per visit. Change out of the oxygen 16-packs was conducted approximately every 2-3 months and was typically performed in under 4 hours. The 6 tanks of liquified propane and 4 tanks of liquified ammonia did not require replacement during 12 months of Phase 2 cometabolic biosparging due to the general efficiency of this treatment approach. The ability to communicate remotely with the system (and adjust gas sparging), as well as programmed logging capabilities of the SCADA system significantly reduced the number of site visits required. Furthermore, other the groundwater sampling purge water, there was no waste generated with during application of this *in situ* technology. The off-the-grid solar powered biosparging system proved simple to operate and maintain.

4.0 SITE DESCRIPTION

A key to the success of any field demonstration project is the selection of an appropriate demonstration site. Site selection included an initial review of the *in-situ* conditions at several cVOC-contaminated DoD facilities. Site data evaluated for each candidate location included the following: (1) basic aquifer conditions (e.g., geology, plume depth, geochemistry, hydrology etc.); (2) cVOC concentrations and plume characteristics; and (3) basic infrastructure (e.g., site access, presence of wells, roads, etc.). Ideal characteristics for evaluation of the demonstration site were as follows:

- Primary contamination < 75 ft below ground surface (ft-bgs)
- Previous assessment of plume characteristics and basic site hydrogeology
- Sandy or silty sand soils without distinct confining layers within the treatment zone
- DO concentrations >1 mg/L
- Neutral groundwater pH
- cVOC concentrations above MCLs, with total cVOC concentrations < 500 µg/L
- Plume width of >100 ft
- Basic infrastructure (roads, existing wells).

Based on the data review, the Building 324 plume at former MBAFB was selected as the optimal site for hosting the field demonstration. Two site visits to MBAFB were made in March 2017. The first visit, on March 8, 2017, included a site walk and evaluation, meetings with Air Force personnel, and collection of groundwater samples from existing wells to confirm contaminant concentrations. The second site visit, on March 28, 2017, included a meeting with Air Force personnel and the case manager from the South Carolina Department of Health and Environmental Control (SCDHEC) to discuss the project. A meeting with personnel from the Myrtle Beach International Airport (the current owner of the facility) was also held during the second site visit to discuss logistics and timing of the field demonstration. A Site Selection Memorandum was submitted to ESTCP on June 14, 2017 (CB&I, 2017), and approved by ESTCP on June 14, 2017.

4.1 SITE LOCATION AND HISTORY

MBAFB is in northeastern South Carolina, approximately 85 miles north of Charleston and 70 miles south of Wilmington, North Carolina (**Figure 4.1**). MBAFB is an inactive US Air Force base that officially closed on March 31, 1993, and land ownership was transferred from the US Air Force to city, county, and civilian use. The Base occupied approximately 3,900 acres within the city of Myrtle Beach in southeastern Horry County, South Carolina. It lies within a geographical area referred to as the Grand Strand, an established resort area along the East Coast. Communities in the vicinity of MBAFB include Myrtle Beach, Socastee, Surfside Beach, and North Myrtle Beach. The airfield portion of the base has been converted for use as the Myrtle Beach International Airport (CB&I, 2016).

A large, dilute cVOC groundwater plume is present downgradient of Building 324 (Site SD019, SWMU 40). Building 324 (see **Figure 4.2**) was a former engine shop where repair, inspection, and routine maintenance of jet engines were performed from 1955 until base closure in March ,1993.

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Figure 4.1. **Project Location Map. Building 324 Plume, Former MBAFB, Myrtle Beach, South Carolina.**

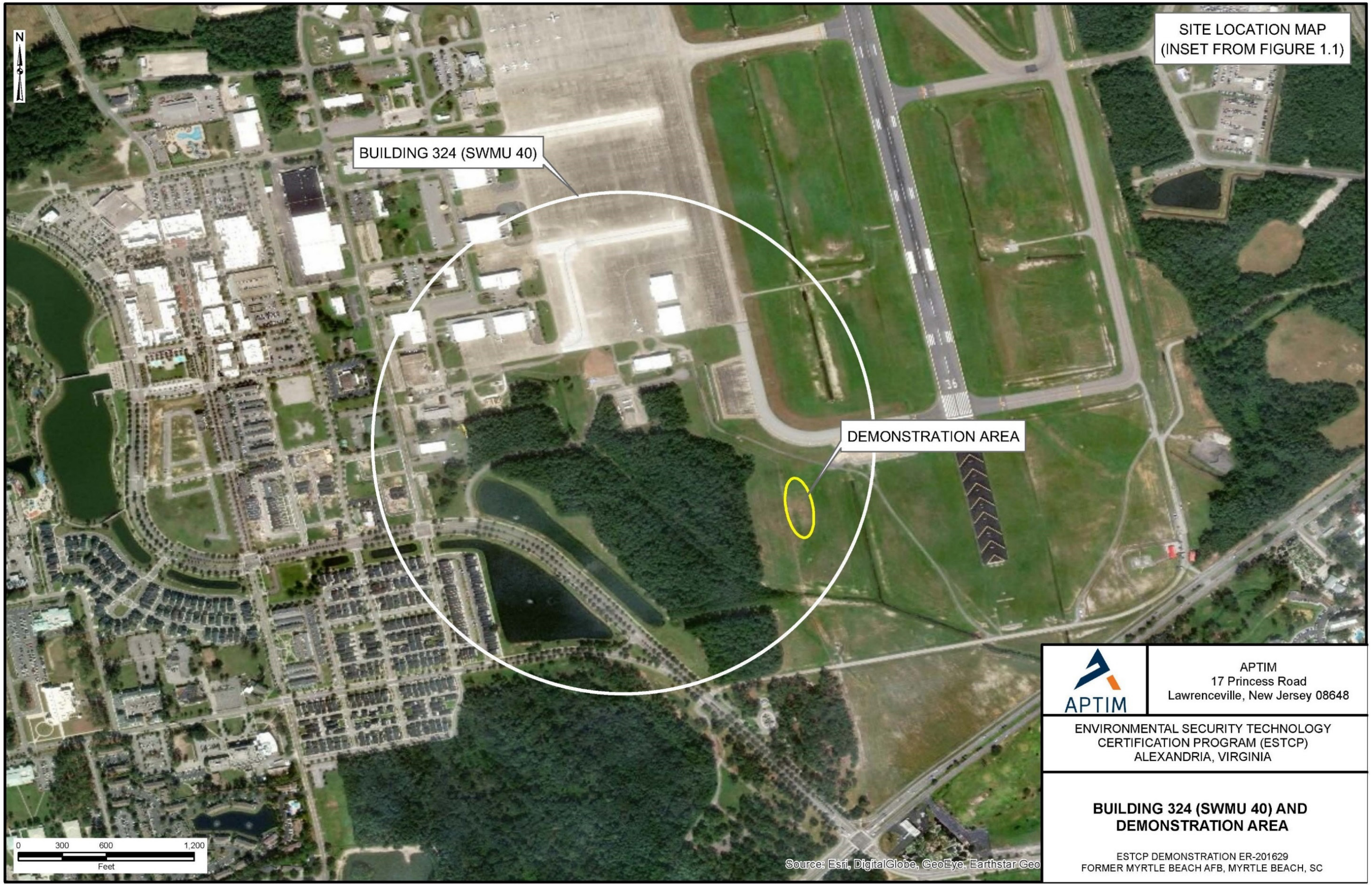

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Figure 4.2. Project Demonstration Area. Building 324 Plume, Former MBAFB, Myrtle Beach, South Carolina.

A solvent vat room, which was used to soak, clean, and rinse aircraft parts, was added in 1965. The room contained five 200-gallon tanks and one 5-gallon tank. The solvent vat drainage system was designed to discharge into an oil/water separator outside the building, which then discharged into the storm drain system. However, a solvent/water mixture was observed to be seeping from the ground after a heavy rain event in 1987, and it was discovered that the drainpipe was never connected to the oil/water separator. After this event, the solvent drainage system was immediately capped to prevent further release, and the drainpipe was removed (CB&I, 2016).

A groundwater extraction and treatment system consisting of five groundwater extraction wells and an air stripping unit was operated between 1995 and 2006. During operation, the system treated up to 140 gallons per minute, and treated groundwater was released to an unnamed stream. A Corrective Measures Study (IT, 2001) established a mass removal performance metric for determining when to turn off the groundwater extraction system and allow MNA to take over the remediation process. The performance metric (20 kilograms of mass removal per year) put in place for this site specified that if the performance metric was not achieved in a given 12-month period, groundwater extraction would cease and MNA would become the primary component of the remedy. After years of downward trends, the mass removal performance metric was not achieved in 2002. As a result, the system was deactivated on March 31, 2003 and remained idle until July 13, 2004. The system was reactivated in July 2004 and operated continually through 2005. The mass removal performance objective was not achieved during this period, and the system was shut down permanently on January 31, 2006. Decommissioning of the treatment system was completed on August 20, 2009. During the operating history of the system, a total of 360.1 million gallons of groundwater was extracted, removing a total of 299 kilograms of chlorinated solvents (Shaw, 2007). Another 15 kilograms of benzene, chlorobenzene, and dichlorobenzenes were also removed by the system.

After the decommissioning of the treatment system, MNA has been relied upon as the primary component of the remedy. While monitoring results for the last several years have shown cVOC attenuation in some wells, cVOC concentrations continue to persist at levels above their respective MCLs and the current projected cleanup time is estimated to extend to 2032 (APTIM, 2018a).

4.2 SITE GEOLOGY/HYDROGEOLOGY

The shallow aquifer across the site extends from the water table (approximately 6 to 12 ft bgs) to a depth of approximately 34 to 55 ft-bgs. The aquifer comprises primarily fine- to medium-grained sands with localized concentrations of shell fragments of up to 30 percent. Sands are predominantly silty, with thin layers of clayey sands. A dense, cemented sand forms the bottom of the shallow aquifer. Because of its saturated thickness, monitoring wells have been installed into the upper and lower portions of the shallow aquifer. Contamination is present in the shallow portion of the aquifer at the source area near Building 324, while groundwater is primarily impacted in the lower portion of the aquifer in downgradient portions of the plume (CB&I, 2016).

Aquifer properties have been evaluated through both slug tests and pumping tests and have been found to vary across the site. Near the source area, the aquifer is approximately 35 ft thick and has an average hydraulic conductivity of 63 ft per day (ft/day). Through the plume core (near former groundwater extraction wells MBEX-01, MBEX-02, and MBEX-03, see **Figure 4.3**), the aquifer is approximately 40 to 55 ft thick, and hydraulic conductivity ranges from 56 to 127 ft/day. At the downgradient edge, near well MBEX-04, the aquifer is approximately 40 ft thick, with an average conductivity of 29 ft/day.

Depth to groundwater in the demonstration area ranges from approximately 6 to 9 ft-bgs. Groundwater elevation contours, based on water table elevation data collected in October 2016, are presented in **Figure 4.3**. The contours indicate that the general direction of groundwater flow in the shallow aquifer is to the southeast. Hydraulic gradients vary across the site, with an average gradient (ambient) of 0.0023 ft per ft based on October 2014 elevations measured between wells MW-110 and MB-35. Using a representative porosity of 0.30, an average gradient of 0.0023, and an average conductivity of 67 ft/day, the ambient groundwater flow rate is estimated at approximately 0.5 ft/day (~180 ft per year) (CB&I, 2016).

4.3 CONTAMINANT DISTRIBUTION

Groundwater cVOC concentration contours from sampling performed in October 2016 and total chlorinated ethene concentration contours, as delineated in 1994, are presented separately in **Figure 4.4**. The 1994 contours were based on data collected from monitoring wells, as well as numerous direct-push groundwater samples collected in the early 1990's. Most of the direct-push samples were collected between wells MB-21 and MB-30, where no monitoring wells are present. These data, while not current, along with persisting *cis*-DCE and VC concentrations at well MB-30, suggest that the plume may be more contiguous and larger than currently drawn.

The demonstration location is located within the downgradient portion of the plume, near monitoring well MB-30 (**Figure 4.4**). As discussed in **Section 1.3**, while *cis*-DCE and VC are the two primary COCs above MCLs in the demonstration area, these compounds are comingled with TCE (the parent compound) in the upgradient portion of the plume. MCLs for these compounds are provided in **Table 1.1**. The following contaminant concentrations were observed in well MB-30 during the October 2016 sampling event:

- TCE: <1 µg/L;
- *cis*-DCE: 110 µg/L; and
- VC: 38.7 µg/L.

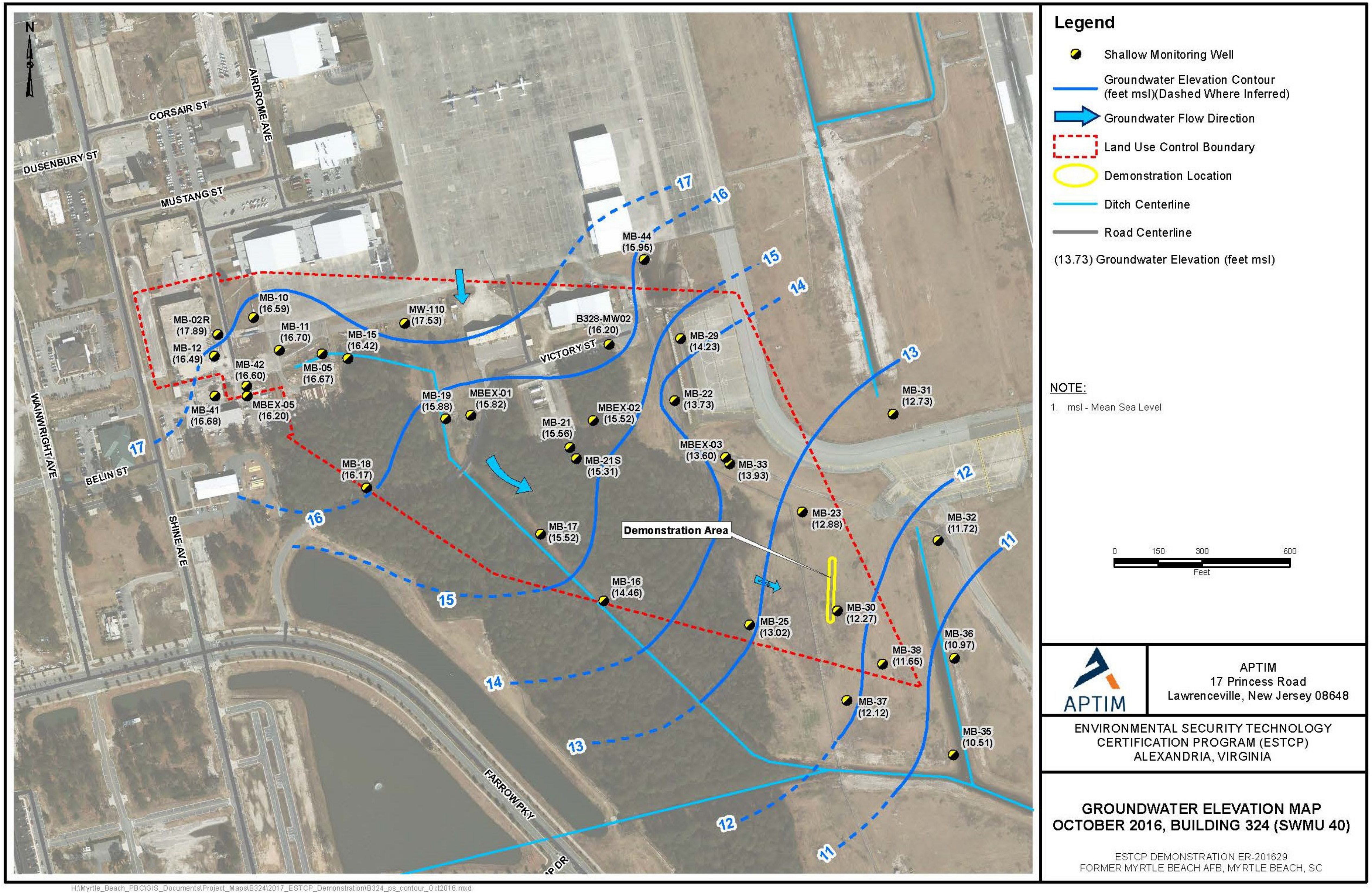
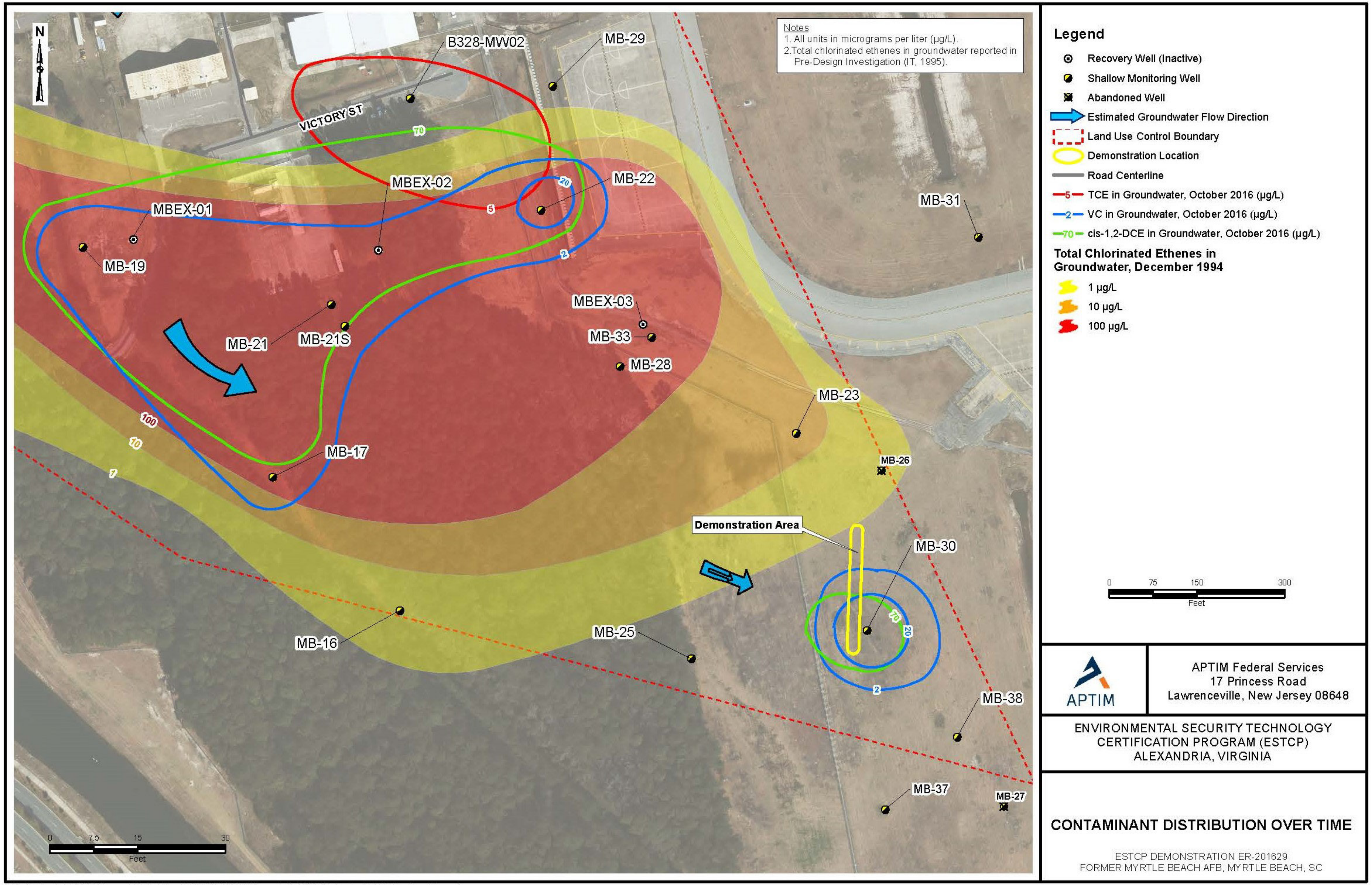


Figure 4.3. Groundwater Elevation Map (October 2016)



Notes
1. All units in micrograms per liter (µg/L).
2. Total chlorinated ethenes in groundwater reported in Pre-Design Investigation (IT, 1995).

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ENVIRONMENTAL SECURITY TECHNOLOGY CERTIFICATION PROGRAM (ESTCP)
ALEXANDRIA, VIRGINIA

CONTAMINANT DISTRIBUTION OVER TIME

ESTCP DEMONSTRATION ER-201629
FORMER MYRTLE BEACH AFB, MYRTLE BEACH, SC

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Figure 4.4. Plume Location and Potential Demonstration Areas

5.0 TEST DESIGN

The following subsections provide detailed description of the system design and testing conducted to address the performance objectives described in **Section 3.0**.

5.1 CONCEPTUAL EXPERIMENTAL DESIGN

As discussed above, this project entailed cometabolic biosparging using a line of vertical biosparging wells installed perpendicular to groundwater flow across the width of a large, dilute cVOC plume containing *cis*-DCE and VC. Contaminated groundwater was treated as it flowed through a biologically active zone created by biosparging oxygen, propane (a primary cometabolic substrate), and ammonia (a source of nitrogen (N)] gases to stimulate indigenous bacteria capable of cometabolically degrading *cis*-DCE and VC. For safety reasons, the oxygen was sparged independently of the propane and ammonia gases, with compressed nitrogen gas used for both flushing the system between sparging cycles, and as a carrier gas for the propane and ammonia.

The automated biosparging system was designed to operate completely "off-the-grid" using solar energy and pressure from gas cylinders to supply necessary amendments. The gases were pulsed into the aquifer via the sparge wells under an optimized flow rate and frequency designed to minimize off-gassing into the vadose zone, while maintaining target dissolved concentrations of the gases to facilitate biomass growth, and ultimately cVOC treatment. During treatment, dissolved propane concentrations decreased via biodegradation over a period of several days/weeks between pulses, so as not to lead to continuous competitive substrate inhibition. In addition to maximizing treatment effectiveness, alkane gas delivery optimization led to the reduction in overall operating costs. Oxygen sparging frequency was also optimized to maintain DO concentrations of at least 3.0 mg/L within a majority of the biobarrier at all times. Details of system operation and safety features are provided in **Section 5.3**.

The demonstration well network (detailed in **Section 5.3.1**) included 22 biosparging wells, 24 discrete-interval performance monitoring wells located within and downgradient of the biobarrier, and two discrete-interval background monitoring wells located upgradient of the biobarrier. Existing monitoring well MB-30, located downgradient of the biobarrier, was also sampled throughout the demonstration to evaluate any reduction in historical cVOC concentrations in this well. The network of groundwater monitoring wells was monitored to evaluate aquifer conditions, including dissolved propane and oxygen, nutrient (total ammonia and nitrate), and cVOC concentrations (as well as other relevant geochemical parameters) in areas within, upgradient and downgradient of the biobarrier. cVOC concentrations measured within and downgradient of the biobarrier were compared with concentrations measured at the upgradient or "Background" wells to evaluate treatment performance.

5.2 BASELINE CHARACTERIZATION ACTIVITIES

Prior to site selection, APTIM reviewed existing site investigation documents and all available hydrogeologic, contaminant concentration, and geochemical data for the MBAFB Building 324 Site. While these data were helpful in the selection of a potential demonstration location within the large dilute plume, additional data were required to assist with design of the field demonstration.

Baseline characterization activities included detailed site characterization and laboratory treatability testing as described in the following subsections.

5.2.1 Site Characterization Activities

Additional site assessment was necessary to assist with the design of the field demonstration. Specifically, site characterization activities were designed to fully delineate the vertical and horizontal extents of contaminants within the proposed demonstration area, evaluate aquifer lithology and hydraulic properties, and to assist in sparge well and biosparging system design. As discussed in greater detail below, site characterization activities included a direct-push technology (e.g., Geoprobe®) soil and groundwater investigation, the installation of sparge testing and monitoring wells, and the implementation of sparge testing. The work also included the collection of soil and groundwater samples to be utilized in laboratory treatability testing (**Section 5.2.2**) that was conducted at APTIM's treatability testing laboratory in Lawrenceville, NJ.

Prior to implementation of site characterization activities, APTIM submitted a Draft Site Characterization Work Plan to the US Air Force Remedial Project Manager (RPM) for MBAFB, on May 30, 2017 for review. Comments and questions were returned to APTIM on June 9, 2017. A revised Site Characterization Work Plan was submitted on June 20, 2017 and was formally accepted by the Air Force on June 30, 2017. This document, along with an Underground Injection Control (UIC) permit application for the injection of oxygen and helium planned during sparge testing (**Section 5.2.1.5**), was submitted to SCDHEC for review and approval on July 20, 2017. The Site Characterization Work Plan and UIC Permit application were approved by SCDHEC on August 1, 2017.

As detailed below, the following site characterization activities were performed between August 22, 2017 and September 22, 2017:

- Advancement of 8 direct-push borings for hydraulic profiling and discrete groundwater sampling;
- Collection of two direct-push continuous soil cores;
- Installation of two vertical sparge testing wells;
- Installation of 12 discrete interval monitoring wells; and
- Installation of 6 vapor probes.

Field activities were conducted using appropriate Level D personal protective equipment (PPE). Underground utility clearances were obtained for all intrusive site activities. Clearance of all underground utilities were arranged through the appropriate Air Force representatives, airport facility personnel, the Palmetto Utility Protection Service, and local utility companies. Additionally, all borehole locations were cleared to 5 ft-bgs using a hand auger.

5.2.1.1 Hydraulic Profiling Borings

Direct-push site characterization activities were performed along the axis of the proposed biobarrier location (**Figure 5.1**) to characterize the subsurface, refine the CSM, and provide critical information for test site selection and remedial design of the biosparging system.

The Geoprobe® Hydraulic Profiling Tool-Groundwater Sampler (HPT-GW) was advanced to a depth of between 38 and 48 ft-bgs at eight locations (HPT-04 through HPT-11), approximately 10 ft from the proposed future path of the biobarrier. Apart from HPT-11, all borings were spaced ~37.5 ft apart. Borings HPT-04, HPT,06, and HPT-08 (spaced 75 ft apart) were advanced first, as part of the initial plume delineation. The remaining borings were subsequently advanced to fully delineate the thickness and edges of the plume.

The HPT-GW subsurface profiling tool combines a hydraulic profiling tool (HPT), an Electric Conductivity (EC) sensor, and a discrete zone groundwater sampler. The HPT is a logging tool that measures the pressure required to inject a flow of water into the soil as a probe is advanced into the subsurface and is an excellent indicator of formation permeability. The horizontal hydraulic conductivity of the subsurface is estimated by software using an empirical relationship developed for the tool. The HPT provided real-time on-screen logs of the subsurface permeability, allowing on-site decisions. During the design phase of the project, the HPT permeability data were analyzed and correlated to sparge testing data to estimate the pathways that the sparged gases would likely take, as well as the vertical and horizontal extent of influence that sparged gases will have. **Figure 5.2** provides a log of EC and HPT data collected at boring HPT-06. This log is fairly consistent with the other 7 logs generated and indicates very permeable soils from the top of the water table (~8 ft-bgs) to a depth of ~34 ft-bgs, with low permeability soils (with some higher permeability stringers) from approximately 34 to 42 ft-bgs. All the HPT logs are presented in **Appendix B**.

Data collected with the EC sensor was useful in classifying soil type and stratigraphy at each boring location. In general, silts and clays exhibit higher electrical conductivity readings than sands and gravels (**Figure 5.2**). The EC logs, in conjunction with HPT logs, were correlated across the study area to map the thickness and elevation of the varying lithologic units of interest and determine the optimal depths to collect discrete groundwater samples. As shown in **Figure 5.2**, the high permeability material identified by the HPT exhibited low electrical conductivity, and the lower permeability material exhibited higher electrical conductivity. Like the HPT, the EC sensor provided real-time on-screen logs, allowing on-site decisions.

5.2.1.2 Continuous Soil Cores

In addition to the advancement of the 8 HPT borings, continuous direct-push soil cores were advanced adjacent to borings HPT-06 and HPT-08 along the transect to verify the lithology represented by the EC and HPT logs. The first of these cores was collected at the start of direct-push activities, in conjunction with the first HPT/EC log (HPT-06), to allow APTIM's on-site geologist to correlate the probe readings to the observed lithology. Visual inspection and geologic logging were used to assess the lithology and to identify lower permeability zones, where present. The HPT and EC logs, along with lithologic logs from the two soil cores (presented in **Appendix B**), were used to create the generalized geologic cross section presented in **Figure 5.3**. The cross section shows 5 distinct lithologic units within the upper ~50 ft of the subsurface. The upper three layers (Fine Sand, Sand and Shell Hash, and Dense Sand), display similar high permeability and estimated horizontal hydraulic conductivity (~90-100 ft/day, as shown in **Figure 5.2**), while being visually distinct from one another. The Clay layer generally displays very low permeability and contains silty clay and/or sandy clay stringers (typically <0.5 ft thick) with somewhat higher permeability. Borings were terminated within the upper portion of the deeper Fine Sand.

A photoionization detector (PID) was used to screen each 5-ft length of soil core collected. No PID readings > 0.0 ppm were observed along any of the cores, indicating the absence of higher cVOC concentrations. Saturated soil core material from the first soil boring was collected for use in the laboratory treatability testing detailed in **Section 5.2.2**.

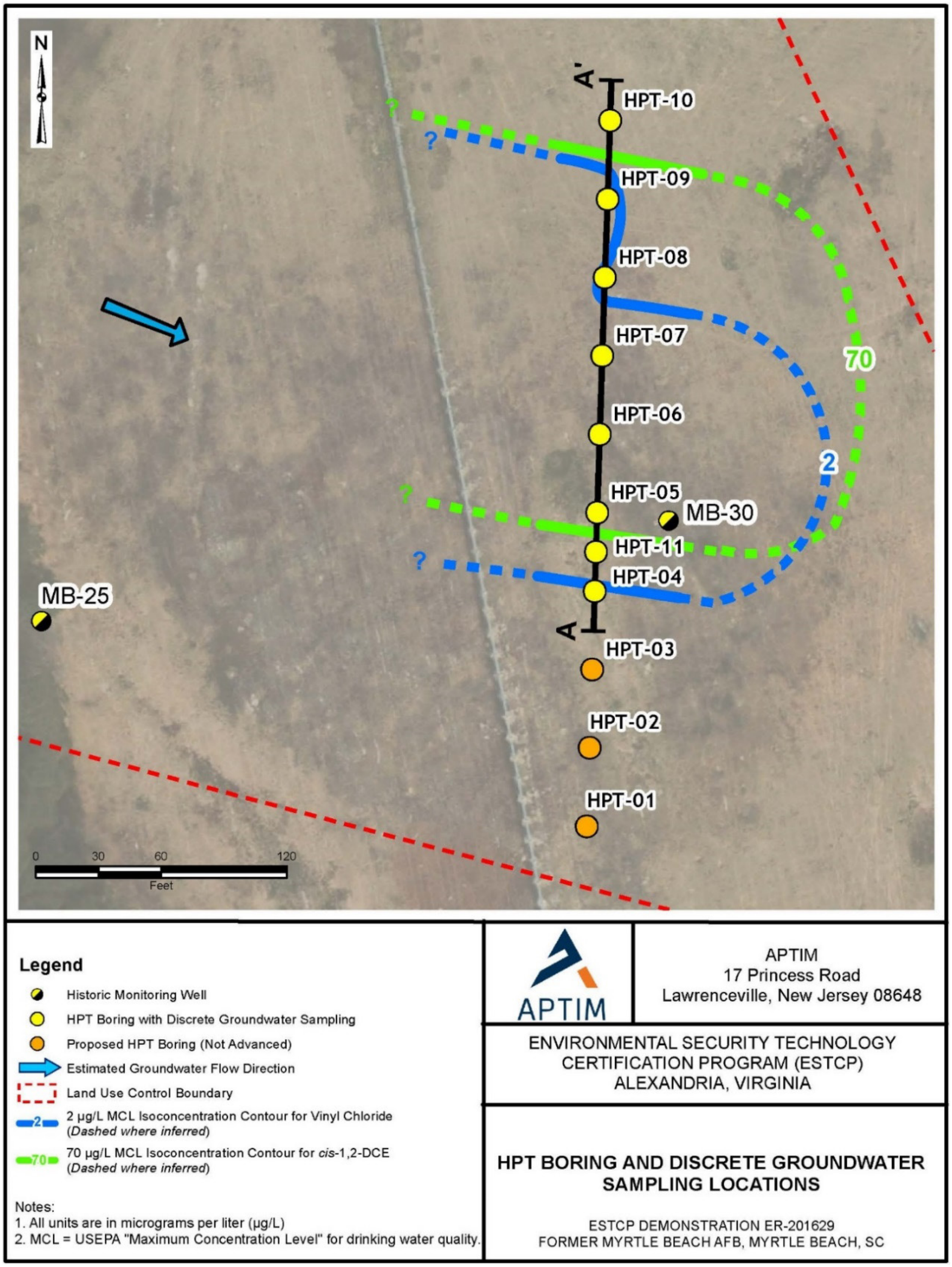


Figure 5.1. HPT Boring and Discrete Groundwater Sampling Locations

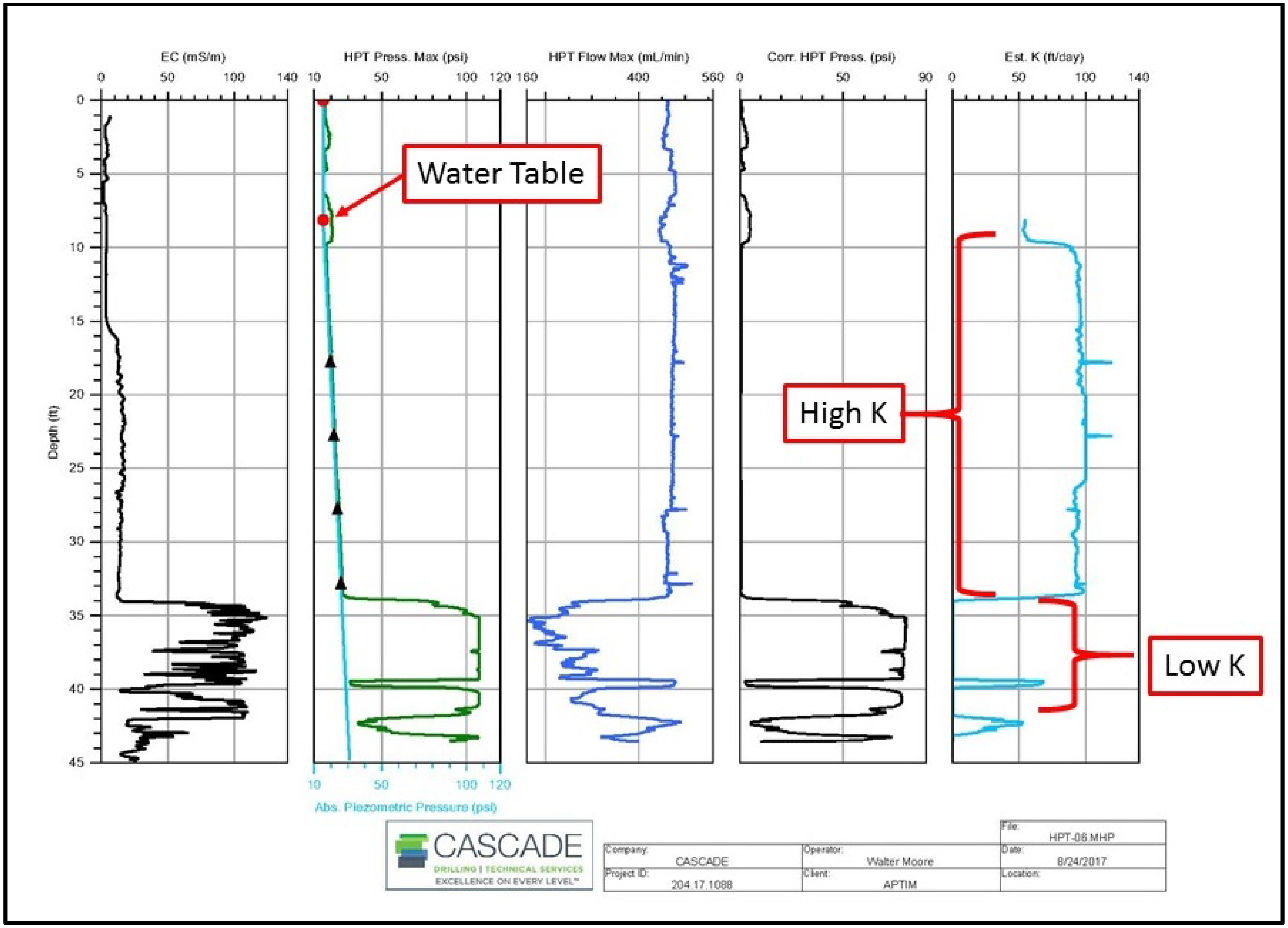
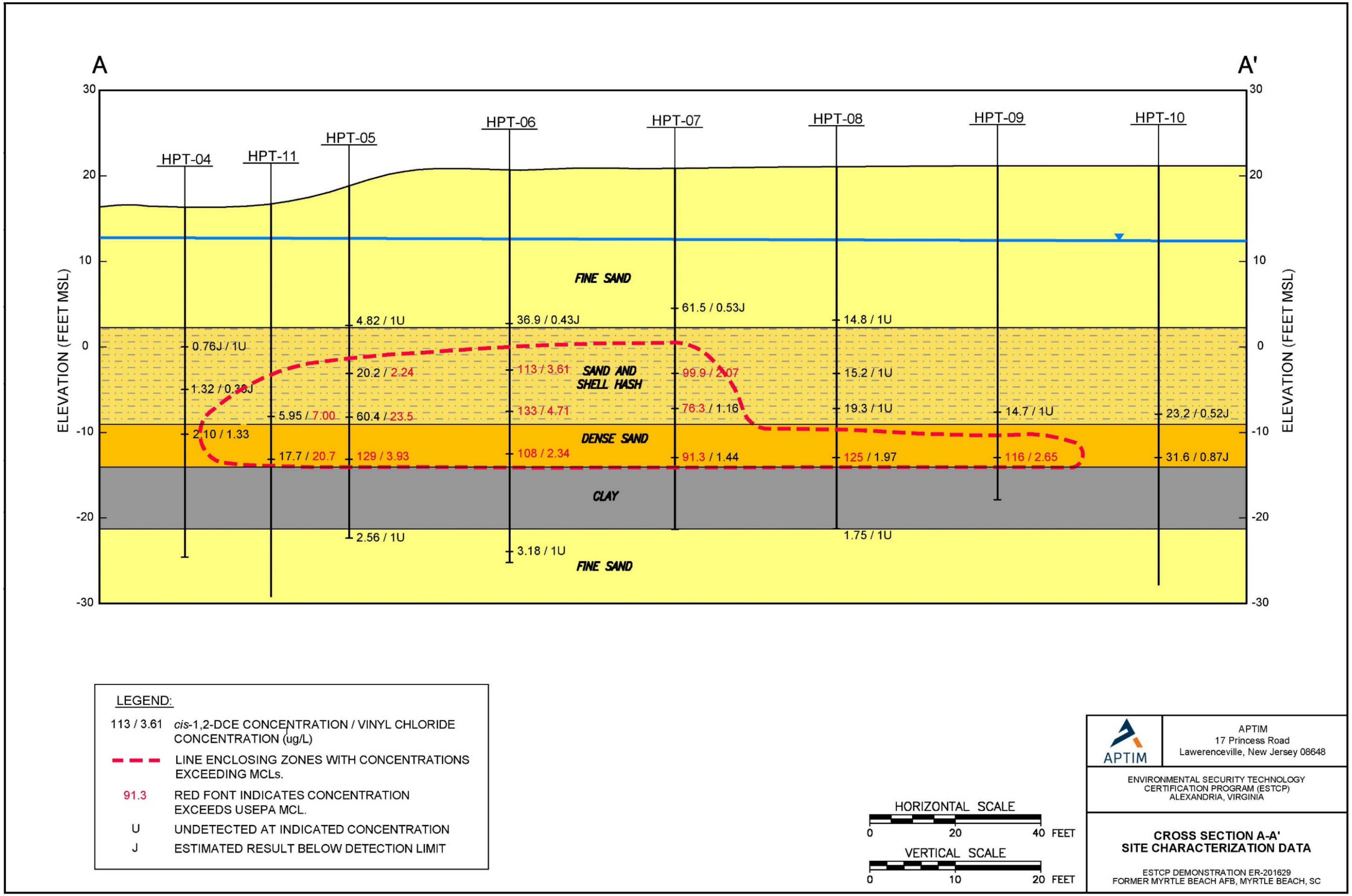


Figure 5.2. HPT and EC Boring Log for HPT-06



LEGEND:

113 / 3.61	*cis*-1,2-DCE CONCENTRATION / VINYL CHLORIDE CONCENTRATION (ug/L)
▬ ▬ ▬	LINE ENCLOSING ZONES WITH CONCENTRATIONS EXCEEDING MCLs.
91.3	RED FONT INDICATES CONCENTRATION EXCEEDS USEPA MCL.
U	UNDETECTED AT INDICATED CONCENTRATION
J	ESTIMATED RESULT BELOW DETECTION LIMIT

APTIM
17 Princess Road
Lawerenceville, New Jersey 08648

ENVIRONMENTAL SECURITY TECHNOLOGY
CERTIFICATION PROGRAM (ESTCP)
ALEXANDRIA, VIRGINIA

CROSS SECTION A-A'
SITE CHARACTERIZATION DATA

ESTCP DEMONSTRATION ER-201629
FORMER MYRTLE BEACH AFB, MYRTLE BEACH, SC

Figure 5.3. Generalized Geologic Cross Section Showing Contaminant Distribution in the Demonstration Area

5.2.1.3 Discrete Groundwater Sampling

Discrete groundwater samples were collected during HPT logging, as the HPT-GW Sampler allows the user to stop the advancement of the probe to obtain groundwater samples from desired depths. Between 2 and 5 discrete groundwater samples were collected at each of the direct-push HPT borings. A total of 28 samples were collected and analyzed for cVOCs (USEPA Method 8260B) and reduced gases (USEPA Method 3810 RSK-175). As shown in **Figure 5.3**, 25 of the samples were collected at 5-ft intervals within the shallow permeable aquifer, and 3 samples were collected below the lower permeability unit (based on permeability data collected from the HPT/EC probe). Sampling within the low permeability unit was not attempted, due to the high HPT pressures observed in this layer (**Figure 5.2**).

Discrete groundwater samples were collected with a peristaltic pump at the surface, connected to dedicated tubing within the HPT-GW Sampler. The discrete sample interval was purged until the groundwater was visually clear; then purge water was directed through a flow-through cell where 3 sets of geochemical parameters [pH, DO, ORP, conductivity, temperature, and turbidity] were measured with a multi-parameter water quality meter (YSI 6920) prior to sample collection. Samples were shipped overnight to APTIM's analytical lab in Lawrenceville, NJ for 24-hr turnaround, facilitating a quick decision-making process in the field.

Table 5.1 summarizes the cVOC (detections only), reduced gases, and field parameter data collected during discrete groundwater sampling. Maximum concentrations of *cis*-DCE and VC observed in the demonstration area were 133 µg/L and 23.5 µg/L, respectively. The measured concentrations are approximately double the MCL for *cis*-DCE (which has a significantly higher MCL than the other cVOCs listed in **Table 1.1**), and an order of magnitude higher than the MCL for VC. TCE was not observed above the MCL in any of the samples collected. Geochemical parameter data indicate that the aquifer is generally anaerobic, with a neutral groundwater pH.

Chlorinated VOC data were used to assess the horizontal and vertical extent of contaminant distribution along the proposed biobarrier transect shown in **Figure 5.1**. HPT-GW Sampling borings were advanced along the transect until groundwater concentrations of *cis*-DCE and VC above Federal MCLs were fully delineated. **Figure 5.3** presents a generalized geologic cross section with contaminant distribution within the demonstration area that was developed using data collected from the HPT/EC logs, soil borings, and discrete groundwater samples. These data indicated that the plume of groundwater concentrations exceeding MCLs is approximately 210 ft wide, and between approximately 5 and 15 ft thick. The plume is located within the Sand and Shell Hash and Dense Sand layers, directly above the low permeability Clay layer (present between approximately 34 and 42 ft-bgs). There were no observed exceedances of MCLs in any of the samples collected below the clay unit.

5.2.1.4 Sparge Testing Well and Vapor Probe Installations

As shown in **Figures 5.4** through **5.6**, two vertical gas sparge testing wells (STW-1S and STW-1D) and 12 discrete interval performance monitoring wells (PMW designation) were installed within the demonstration area. This group of vertical wells was located near the center of the groundwater plume (as observed during the direct-push sampling activities discussed above) and was used during sparge testing (**Section 5.2.1.5**). Additionally, these wells were located within and immediately downgradient of the biobarrier and were used for performance monitoring during the demonstration.

Table 5.1. Summary of HPT-GW Sampling Data

	HPT-04			HPT-11		HPT-05					HPT-06				
Depth (ft-bgs)	16	21	26	24	29	16	21	26	31	40*	18	23	28	33	44*
VOCS (GC/MS)	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
vinyl chloride	1 U	0.38 J	1.33	7.00	20.7	1 U	2.24	23.5	3.93	1 U	0.43 J	3.61	4.71	2.34	1 U
cis 1,2- dichloroethylene	0.76 J	1.32	2.10	5.95	17.7	4.82	20.2	60.4	129	2.56	36.9	113	133	108	3.18
trichloroethylene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1.54	1 U	1 U	0.33 J	0.44 J	0.57 J	1 U
REDUCED GASES (GC)	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	82.2	146	103	111	228	48.9	99.8	435	453	47.1	112	517	594	561	21.3
Ethane	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U
Ethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	6.95	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Propane	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U
FIELD PARAMETERS															
pH (SU)	7.18	7.05	6.85	6.95	6.80	6.60	6.92	6.78	6.95	7.56	6.78	6.90	7.01	6.94	7.61
Temperature (°C)	26.06	26.58	25.21	28.54	27.79	23.21	24.44	23.90	24.44	26.28	24.63	25.11	27.33	27.07	31.31
Dissolved Oxygen (DO; mg/L)	0.62	0.57	0.17	0.11	0.08	0.22	0.08	0.12	0.10	0.11	1.09	1.30	0.75	0.97	1.05
Redox Potential (ORP; mV)	-72.3	-61.8	-56.5	-96.4	-109.9	-7.0	-89.4	-67.1	-69.3	21.8	-34.6	-57.3	-65.1	-83.5	-54.9
Conductivity (mS/cm)	0.598	1.001	0.886	1.406	1.424	0.791	1.362	1.359	1.341	0.769	1.046	1.046	1.033	1.002	0.618
Turbidity (NTU)	123.7	7.8	33.8	-2.1	15.3	21.2	2.6	11.8	27.9	19.2	70.5	30.0	6.3	46.8	8.2
Purge Rate (mL/min, approximate)	330	230	NR	NR	NR	NR	NR	NR	NR	NR	453	385	345	310	140

	HPT-07				HPT-08					HPT-09		HPT-10	
Depth (ft-bgs)	18	23	28	33	18	23	28	33	40*	28	33	28	33
VOCS (GC/MS)	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
vinyl chloride	0.53 J	2.07	1.16	1.44	1 U	1 U	1 U	1.97	1 U	1 U	2.65	0.52 J	0.87 J
cis 1,2- dichloroethylene	61.5	99.9	76.3	91.3	14.8	15.2	19.3	125	1.75	14.7	116	23.2	31.6
trichloroethylene	0.29 J	0.48 J	0.26 J	0.98 J	0.38 J	1.35	0.76 J	1.20	1 U	0.23 J	1.18	1 U	0.72 J
REDUCED GASES (GC)	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	387	650	537	694	145	93.0	217	887	105	1,200	1,260	468	314
Ethane	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U	4 U
Ethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Propane	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U
FIELD PARAMETERS													
pH (SU)	6.60	6.75	6.80	6.85	7.00	7.06	7.07	7.13	7.63	7.10	6.95	6.54	6.94
Temperature (°C)	23.71	23.50	24.15	24.76	27.55	28.33	26.78	27.67	28.45	24.11	23.34	21.45	22.25
Dissolved Oxygen (DO; mg/L)	0.14	0.10	0.09	0.07	0.19	0.08	0.06	0.07	0.06	0.12	0.06	0.13	0.08
Redox Potential (ORP; mV)	4.7	-80.8	-74.3	-91.7	-90.0	-98.9	-100.5	-104.4	-17.2	-103.9	-99.7	20.4	-84.5
Conductivity (mS/cm)	1.174	1.313	1.321	1.393	0.850	1.108	1.074	0.897	0.518	1.164	1.301	1.129	1.344
Turbidity (NTU)	7.5	17.1	-3.3	-4.0	22.6	-1.8	3.2	4.6	-1.2	4.7	29.9	16.7	25.2
Purge Rate (mL/min, approximate)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

Notes:

🟧 compound exceeds MCLs

NR - Not Recorded

*sample depth rounded up to nearest foot

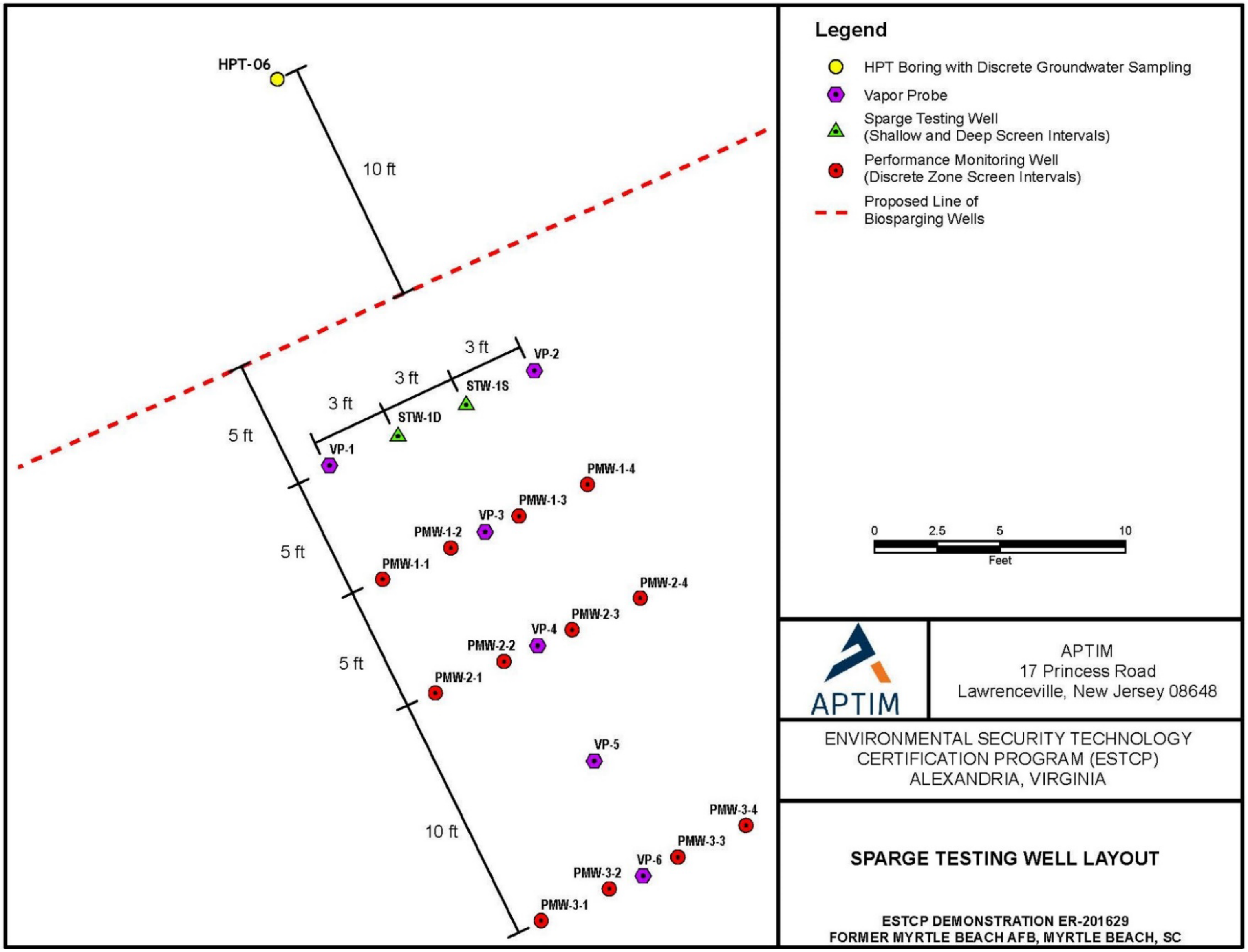


Figure 5.4. Sparge Testing Well Layout

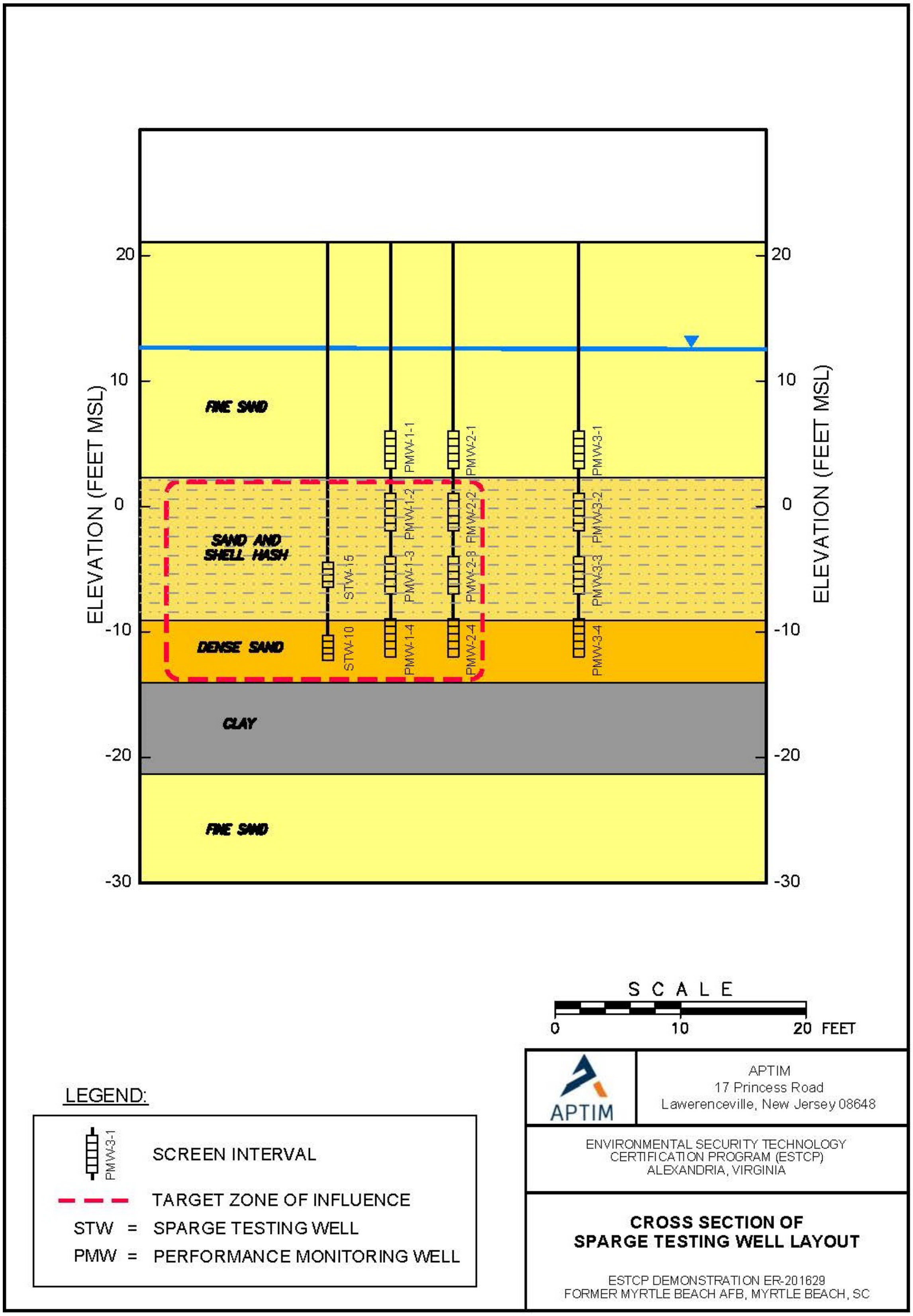


Figure 5.5. Cross Section of Sparge Testing Well Layout

Figure 5.6. Photograph of Sparge Testing Well Plot Looking Downgradient

All wells were installed using direct-push technology drilling techniques. Drilling and well construction was performed by a South Carolina-licensed driller and supervised by an APTIM geologist. Each well was constructed of 1.25-in inner diameter (ID) Schedule 40 polyvinyl chloride (PVC) casing, with a 2-ft long pre-packed screen for the sparge wells, and a 3-ft long pre-packed screen for the monitoring wells. As-built well construction details are provided in **Table 5.2**.

The vertical gas sparge test wells were installed in adjacent boreholes screening two separate vertical intervals (**Figure 5.5**); one in the approximate middle of the plume (25.4-27.4 ft-bgs), and one at the bottom of the plume (31.2-33.2 ft-bgs). As shown in **Figure 5.4**, four discrete interval PMWs were installed adjacent to each other in three clusters (each in a line, spaced ~3 ft apart), to allow for the monitoring of four discrete vertical groundwater zones at each cluster location. The clusters are located approximately 5 ft, 10 ft, and 20 ft downgradient from the sparge wells (see **Figures 5.4** through **5.6**). The vertical and horizontal distribution of these wells were designed for assessment of gas distribution during sparge testing. Three of the four wells in each cluster span the vertical extent of the plume identified during the direct-push investigation. The fourth well is screened just above the plume. There is approximately 2 ft of vertical spacing between screen intervals at each well cluster.

Borings for each well were advanced to their pre-determined depth using 3.75-inch OD direct-push rods with an expendable point. The wells were assembled and installed through the rods to the target depth. The expendable point was then dislodged, and the rod string was slowly retracted, allowing the surrounding formation to collapse until the leading end of the rods was 1 ft above the top of the well screen. A seal consisting of coated ¼-inch bentonite tablets (Cetco® coated tablets) was added from the top of the collapsed formation to 13 ft-bgs (approximately 5-7 ft below the water table) as the rod string was retracted further. The extended bentonite seal was used instead of bentonite-cement grout throughout portions of the annular space to eliminate the possibility of grout impacting neighboring well screens (located as close as 3 ft away).

The coated ¼-inch bentonite tablets are designed to fall through water columns without "bridging" and were small enough to be installed within the annular space of the borehole (providing a continuous annular seal). A bentonite-cement grout was then installed to fill the remaining annular space to within 1 ft of the ground surface as the remaining rod string was removed. The wells were completed with 8-inch steel flush-mount well vaults set in individual concrete pads (**Figure 5.6**). Upon completion, locking caps and labeled identification plates were installed on each well. Well construction logs for each of the wells are presented in **Appendix B**.

Table 5.2. As-Built Sparge Testing Well and Vapor Probe Construction Details

Location ID	Approximate Distance from Sparge Wells (ft)	Well Diameter (in)	Borehole Diameter (in)	Pre-packed Screen Length[1] (ft)	Sump Interval (ft. bgs)	Screen Interval (ft. bgs)	Filter Pack Interval[2] (ft. bgs)	Bentonite Seal Interval[3] (ft. bgs)	Grout Interval[4] (ft. bgs)
Sparge Testing Wells									
STW-1S	NA	1.25	3.75	2.0	27.4 - 27.7	25.4 - 27.4	25.0 - 27.7	13.0 - 25.0	1.0 - 13.0
STW-1D	NA	1.25	3.75	2.0	33.2 - 33.5	31.2 - 33.2	31.0 - 33.5	13.0 - 31.0	1.0 - 13.0
Performance Monitoring Wells									
PMW-1-1	5	1.25	3.75	3.0	18.1 - 18.4	15.1 - 18.1	13.0 - 18.4	12.0 - 13.0	1.0 - 12.0
PMW-1-2	5	1.25	3.75	3.0	22.8 - 23.1	19.8 - 22.8	19.0 - 23.1	12.0 - 19.0	1.0 - 12.0
PMW-1-3	5	1.25	3.75	3.0	27.9 - 28.2	24.9 - 27.9	24.0 - 28.2	12.0 - 24.0	1.0 - 12.0
PMW-1-4	5	1.25	3.75	3.0	33.0 - 33.3	30.0 - 33.0	29.0 - 33.3	13.0 - 29.0	1.0 - 13.0
PMW-2-1	10	1.25	3.75	3.0	18.0 - 18.3	15.0 - 18.0	13.0 - 18.3	12.0 - 13.0	1.0 - 12.0
PMW-2-2	10	1.25	3.75	3.0	22.9 - 23.2	19.9 - 22.9	18.0 - 23.2	12.0 - 18.0	1.0 - 12.0
PMW-2-3	10	1.25	3.75	3.0	27.4 - 27.7	24.4 - 27.4	24.0 - 27.7	13.0 - 24.0	1.0 - 13.0
PMW-2-4	10	1.25	3.75	3.0	32.7 - 33.0	29.7 - 32.7	28.7 - 33.0	13.0 - 28.7	1.0 - 13.0
PMW-3-1	20	1.25	3.75	3.0	18.1 - 18.4	15.1 - 18.1	13.0 - 18.4	12.0 - 13.0	1.0 - 12.0
PMW-3-2	20	1.25	3.75	3.0	23.1 - 23.4	20.1 - 23.1	19.0 - 23.4	13.0 - 19.0	1.0 - 13.0
PMW-3-3	20	1.25	3.75	3.0	27.8 - 28.1	24.8 - 27.8	23.8 - 28.1	13.0 - 23.8	1.0 - 13.0
PMW-3-4	20	1.25	3.75	3.0	32.5 - 32.8	29.5 - 32.5	28.5 - 32.8	13.0 - 28.5	1.0 - 13.0
Vapor Probes									
VP-1	3	0.75	4.0	0.5	3.8 - 3.9	3.2 - 3.8	3.0 - 3.9	2.0 - 3.0	1.0 - 2.0
VP-2	3	0.75	4.0	0.5	3.8 - 3.9	3.2 - 3.8	3.0 - 3.9	2.0 - 3.0	1.0 - 2.0
VP-3	5	0.75	4.0	0.5	3.8 - 3.9	3.2 - 3.8	3.0 - 3.9	2.0 - 3.0	1.0 - 2.0
VP-4	10	0.75	4.0	0.5	3.8 - 3.9	3.2 - 3.8	3.0 - 3.9	2.0 - 3.0	1.0 - 2.0
VP-5	15	0.75	4.0	0.5	3.8 - 3.9	3.2 - 3.8	3.0 - 3.9	2.0 - 3.0	1.0 - 2.0
VP-6	20	0.75	4.0	0.5	3.8 - 3.9	3.2 - 3.8	3.0 - 3.9	2.0 - 3.0	1.0 - 2.0

Notes:

[1] Vapor probe screens are Sch. 40 PVC slotted screen, not pre-packed screens.

[2] Filter pack interval includes pre-packed screen and formation material (sand) that was left to collapsed as the direct-push rods were retracted.

[3] Bentonite seal consists of 1/4" coated bentonite tablets installed to ~11' to 13' bgs (approximately 5' below the water table).

[4] Grout composed of cement bentonite grout, installed from the top of the bentonite seal to within 0.5 to 1.5' of the ground surface.

ft = feet

bgs = below ground surface

The wells were developed using a peristaltic pump and a surge block, and water was not added to the well to aid in development. Well development was accomplished by surging the well, followed by pumping groundwater until the water was clear and the well was sediment free to the extent practical.

Six vapor probes, VP-1 through VP-6 (see **Figure 5.4**) were installed in the vadose zone to 4 ft-bgs using a hand auger. These wells were installed to assess any potential sparge gas migration up into the vadose zone that could occur during testing. Each probe was constructed of ¾-inch diameter Schedule 40 PVC casing, with a 6-inch long Schedule 40 PVC screen containing 0.010-inch slots. A filter pack consisting of 20/40 mesh silica sand was installed in the annular space from the screen bottom to 6 inches above the screen. A 2-ft bentonite seal consisting of granular bentonite (30-mesh) was placed above the filter pack and hydrated in 6-inch lifts. A bentonite-cement grout filled the remaining annular space to within 1-ft of the ground surface. The probes were completed with 6-inch steel flush-mount well vaults set in individual concrete pads (**Figure 5.6**). All wells and vapor probes were surveyed for elevation and Northing and Easting coordinates with respect to an established benchmark by a professional surveyor.

5.2.1.5 Sparge Testing

An initial round of sparge testing was performed on October 10, 2017, with subsequent testing on November 15 and 16, 2017. Sparging was performed at shallow sparge well STW-1S, deep sparge well STW-1D, and discrete-interval monitoring wells PMW-2-2 and PMW-2-3 (locations shown on **Figures 5.4** and **5.5**), for a total of eight sparge tests. During each of the sparge tests, oxygen and helium were sparged simultaneously into the test well. Compressed oxygen and helium gas cylinders were mobilized to the site, fitted with appropriate two-stage regulators and gas tubing made of compatible materials (**Figure 5.7**). A threaded PVC fitting was glued onto each of the sparge wells, and a temporary sparging well head was threaded onto the fitting prior to testing. As shown in **Figure 5.7**, the well head included a pressure gauge and manual pressure relief valve.

Figure 5.7. Photographs of Sparge Testing Setup

During sparging, oxygen and helium gas flow rates were measured using gas-specific mass flow meters (**Figure 5.7**) prior to combining the gas streams for injection. Flow rates for each of the gases were controlled using needle valves. Target helium injection concentrations were approximately 10 percent of the total gas injection flow. However, due to the limited measurement range of the helium mass flow meter, helium could not always be added at the target concentration. Therefore, helium was added at higher percentages (33%) during testing at lower total gas (oxygen plus helium) flow rates, and at lower percentages (5%) during testing at higher total gas flow rates, so that helium flow rates could be accurately measured by the mass flow meter.

As summarized in **Table 5.3**, two sparge tests involved sparging at continuous rates, four tests involved increasing the flow rate in a step-wise fashion, and two tests involved pulsing of the gases. The duration of individual sparge tests ranged from 38 to 107 minutes, with combined oxygen and helium sparge rates between 0.75 and 10.5 standard cubic ft per minute (SCFM). The two sparge tests where pulsing was performed were conducted at deep sparge well PMW-1D to evaluate the potential effects of pulsing on gas distribution within the aquifer. A total of 2,034 cubic ft (169 lbs.) of oxygen and 214 cubic ft (2.36 lbs.) of helium were injected during the eight tests.

Table 5.3. Summary of Sparge Testing Parameters

Date	Sparge Well	Oxygen Sparge Rate (SCFM)	Helium Sparge Rate (SCFM)	Combined Sparge Rate (SCFM)	Percent Helium	Duration (minutes)	Oxygen Sparged (cubic ft.)	Oxygen Sparged (lb.)	Helium Sparged (cubic ft.)	Helium Sparged (lb.)
STW-1D Step Test										
10/10/2017	STW-1D	2.5	0.3	2.8	11	63	158	13.1	18.9	0.21
10/10/2017	STW-1D	5.0	0.6	5.6	11	18	90	7.5	10.8	0.12
STW-1S Step Test										
10/10/2017	STW-1S	2.5	0.25	2.75	9	49	123	10.2	12.3	0.13
10/10/2017	STW-1S	5.0	0.6	5.6	11	35	175	14.5	21.0	0.23
STW-1D Constant Rate Test										
11/15/2017	STW-1D	0.5	0.25	0.75	33	76	38	3.2	19.0	0.21
STW-1D Pulse Test										
11/15/2017	STW-1D	0.5	0.25	0.75	33	15	7.5	0.6	3.8	0.04
11/15/2017	STW-1D	0.5	0.25	0.75	33	10	5.0	0.4	2.5	0.03
11/15/2017	STW-1D	0.5	0.25	0.75	33	10	5.0	0.4	2.5	0.03
STW-1D Step Test										
11/15/2017	STW-1D	1.0	0.15	1.15	13	68	68	5.6	10.2	0.11
11/15/2017	STW-1D	5.0	0.5	5.5	9	39	195	16.2	19.5	0.21
PMW-2-3 Step Test										
11/16/2017	PMW-2-3	2.0	0.25	2.25	11	67	134	11.1	16.8	0.18
11/16/2017	PMW-2-3	5.0	0.5	5.5	9	40	200	16.6	20.0	0.22
STW-1D Pulse Test										
11/16/2017	STW-1D	10.0	0.5	10.5	5	18	180	14.9	9.0	0.10
11/16/2017	STW-1D	10.0	0.5	10.5	5	20	200	16.6	10.0	0.11
PMW-2-2 Constant Rate Test*										
11/16/2017	PMW-2-2	6.0	0.5	6.5	8	43	258	21.4	21.5	0.24
11/16/2017	PMW-2-2	6.0	0.5	6.5	8	33	198	16.4	16.5	0.18
					Totals	**604**	**2034**	**169**	**214**	**2.36**

Note:

* Constant rate sparging at PMW-2-2 was interrupted for 5 minutes during oxygen cylinder change out.

The 12 newly installed performance monitoring wells, two sparge wells, and nearby existing monitoring well MB-30 were monitored in the field for DO and groundwater elevation prior to (baseline) and during sparging to determine the horizontal and vertical influence of the oxygen sparging. DO concentrations were measured via a combination of dedicated and non-dedicated DO meters. Groundwater elevations were measured manually at all wells during each of the tests, and continuously at select wells using dedicated transducers during testing on November 15 and 16, 2017. Vapor samples were periodically collected in Tedlar bags from the six vadose zone vapor probes using a vacuum pump. These samples were analyzed in the field for helium using a handheld helium gas detector, as well as for cVOCs, oxygen, hydrogen sulfide, carbon monoxide, and percent of the lower explosive limit (LEL) using a portable handheld multi-gas detector to determine if sparged gases were reaching or impacting the vadose zone. Periodic direct readings for the gases listed above were also collected from the headspace of select monitoring wells during testing on November 16, 2017.

The first sparge test was performed at deep sparge well STW-1D to determine the horizontal and vertical distribution of oxygen while sparging at the bottom of the plume. This sparge well is screened at the bottom of the Dense Sand layer, with the top of the screen located approximately 3 ft below the bottom of the Shell Hash layer (**Figure 5.5**). As summarized in **Table 5.3**, a two-step sparge test with total gas flow rates of 2.8 SCFM (step 1) and 5.6 SCFM (step 2) was conducted at STW-1D. Based on the high permeability and hydraulic conductivities of these two lithologic layers (between ~80 and 100 ft/day) estimated during site characterization activities (e.g., HPT borings), it was anticipated that significant upward distribution of sparged gases (>10 ft) would be observed in a relatively short period of time. However, increases in DO concentrations were only observed in the closest monitoring well (PMW-1-4, also screened within the Dense Sand layer) located 5’ away, and the two wells screened within the deepest portion of the Shell Hash layer (PMW-1-3 and PMW-2-3, located 5’ and 10’ away, **Figures 5.4** and **5.5**). Increases in DO concentrations were not observed in any of the monitoring wells screened within the middle or upper portions of the Shell Hash layer (screened ~10’ and 15’ above the sparge well). A small temporal increase in DO concentrations was measured in shallow sparge well STW-1S, which is located 3’ away from the deep sparge well and is screened ~5’ above the sparging interval.

Based on the limited vertical distribution of DO observed during the first sparge test, a subsequent sparge test was performed at shallow sparge well STW-1S. As summarized in **Table 5.3**, a two-step sparge test with total gas flow rates of 2.75 SCFM (step 1) and 5.6 SCFM (step 2) was conducted. Results from this test showed increases in DO concentrations at wells PMW-1-3 and PMW-1-4, both located 5’ away (**Figures 5.4** and **5.5**). PMW-1-3 is screened at the same approximate depth as the shallow sparge well (near the bottom of the Shell Hash layer), while PMW-1-4 is screened 5’ deeper (within the Dense Sand layer). Increases in DO concentrations were not observed in any other monitoring wells during this test.

Increases in water levels of up to approximately 2 ft. were observed immediately after the initiation of sparging during both tests, indicating hydraulic connection within the test zone. However, groundwater mounding was generally greater at wells that were screened in the same interval as the sparge wells, compared to shallower wells that were the same distance away. Detections of helium and/or changes to the vadose zone gas composition were not observed in any of the vapor probe samples collected during sparge testing, indicating that sparged gases were not reaching the vadose zone.

Observed gas flow breakout and operational pressures were below 12 psi, which is significantly below the overburden pressure, and optimal for the design of the biosparging system.

The data collected during these two tests suggested that, while exhibiting high horizontal hydraulic conductivity, the Shell Hash layer has a much lower (probably orders of magnitude) vertical hydraulic conductivity and is extremely anisotropic. Subsequent testing performed on November 15 and 16, 2017 at multiple wells (see **Table 5.3**) confirmed this to be the case. The reason for the anisotropy is likely the composition of the Shell Hash layer, which consists of approximately 20-30% small (typically <2-3 mm) shell fragments. Most of these shell fragments were likely deposited in the horizontal position, creating bedding-like features that significantly reduce the vertical distribution of gasses during sparging. While this scenario is not ideal for the use of horizontal sparge wells (which were originally proposed for this project and work best when sparged gases are easily distributed in the upward vertical direction), the sparge testing data collected indicate that sparging at 3 different vertical intervals would likely distribute gases sufficiently throughout the 15' plume thickness. Additionally, based on observed area of influence during sparge testing, it is estimated that at a sparge rate of 10 SCFM, vertical sparge wells located on 20-ft centers would provide the desired horizontal gas distribution within the aquifer.

Based on these findings, several sparge well configurations were evaluated to create a cometabolic sparging biobarrier that would span the entire cross-sectional area of the plume (as shown in **Figure 5.3)**. These configurations consisted of (1) three horizontal sparge installed at 3 different vertical intervals, (2) several vertical sparge wells installed at 3 different vertical intervals, and (3) a combination of both types of wells (with a horizontal sparge well installed at the bottom of the Dense Sand layer, and vertical sparge wells installed at 2 different vertical intervals within the Shell Hash layer). The evaluation of these alternatives included estimated costs, as well as impacts on the biosparging system design and operation. The results of the evaluation indicated that the use of multiple vertical sparging wells installed at three different vertical intervals would provide optimal distribution of the gases in the subsurface, give additional flexibility associated with biosparging system design and operation, and be the most cost-effective alternative. Utilizing multiple vertical sparging wells allowed for sparging at one well at a time (e.g., cycling through wells) at a total flow rate of ~10-15 SCFM, which requires lower instantaneous flow rates of the sparged gases than that required by a single horizontal sparge well with a long screen interval (~50-60 SCFM), thus minimizing the size of some of the biosparging system components. Additionally, the installation of vertical sparge wells using direct-push methods does not generate soil cuttings, which would require off-site disposal. It should be noted that the choice to use vertical sparge wells instead of horizontal sparge wells during this demonstration was based primarily on results of the site characterization data (mostly sparge testing results) and is not intended to suggest that horizontal sparge wells could not be effective at distributing gases in hydrogeologic settings that are not as unique (e.g., anisotropic shell hash) as those encountered at this site. To the contrary, horizontal wells have been used successfully for AS/SVE and biosparging in a wide range of hydrogeologic environments.

5.3 LABORATORY TREATABILITY TESTING

Laboratory treatability testing was performed at APTIM's treatability study laboratory located in Lawrenceville, NJ, and consisted of microcosm testing with site materials and batch kinetic studies using select enrichments from the microcosm tests. A Laboratory Treatability Study Plan was submitted to ESTCP for review on July 6, 2017 and was approved without comment on

September 8, 2017. The results of the testing are summarized in the following two subsections, with details provided in the Treatability Study Report (APTIM, 2018b), located in **Appendix C.**

5.3.1 Microcosms

Soil collected from the first continuous soil boring (see **Section 5.2.1.2**) and 8 L of groundwater collected from monitoring well MB-30 were used to prepare aquifer microcosms. The primary objectives of the microcosm study were to determine the efficacy of oxygen and various alkane/alkene gases (propane, methane, ethene, and natural gas) to stimulate co-metabolic treatment of target cVOCs (*cis*-DCE and VC) by indigenous microbial populations, and to estimate oxygen and substrate gas utilization rates. Various gaseous nutrients were also evaluated, including nitrous oxide (N_2O), methylamine and ammonia as sources of N, and triethyl phosphate (TEP) as a source of phosphorous (P). A summary of the initial set of microcosm treatments (which did not include ammonia as a nutrient) is provided in **Table 5.4**.

Table 5.4. Summary of Microcosm Treatments

			Alkane/Alkene Gas			
Treatment Number	**Treatment Description**	**Headspace**	**Gas Purity (%)**	**Headspace (%)**	**Aqueous Concentration (ug/L)**	**Inorganic Nutrients Added**
Triplicate Microcosms						
1	Killed Control + Methane*	Air	99.0	3.8	850	Yes
2	Live + TEP & N_20	Air	NA	NA	NA	Yes
3	Live + TEP & Methylamine	Air	NA	NA	NA	Yes
4	Propane	Air	99.0	1.5	1000	No
5	Propane + TEP & N_20	Air	99.0	1.5	1000	Yes
6	Propane + TEP & Methylamine	Air	99.0	1.5	1000	Yes
7	Methane	Air	99.5	3.8	850	No
8	Methane + TEP & N_20	Air	99.5	3.8	850	Yes
9	Methane + TEP & Methylamine	Air	99.5	3.8	850	Yes
10	Ethene	Air	99.5	1.1	1500	No
11	Ethene + TEP & N_20	Air	99.5	1.1	1500	Yes
12	Ethene + TEP & Methylamine	Air	99.5	1.1	1500	Yes
13	Natural Gas	Air	~95	3.8	850	No
14	Natural Gas + TEP & N_20	Air	~95	3.8	850	Yes
15	Natural Gas + TEP & Methylamine	Air	~95	3.8	850	Yes
Duplicate Microcosms						
16	Propane + DAP	Air	99.0	1.5	1000	Yes
17	Methane + DAP	Air	99.5	3.8	850	Yes
18	Ethene + DAP	Air	99.5	1.1	1500	Yes
19	Natural Gas + DAP	Air	~95	3.8	850	Yes

Notes:

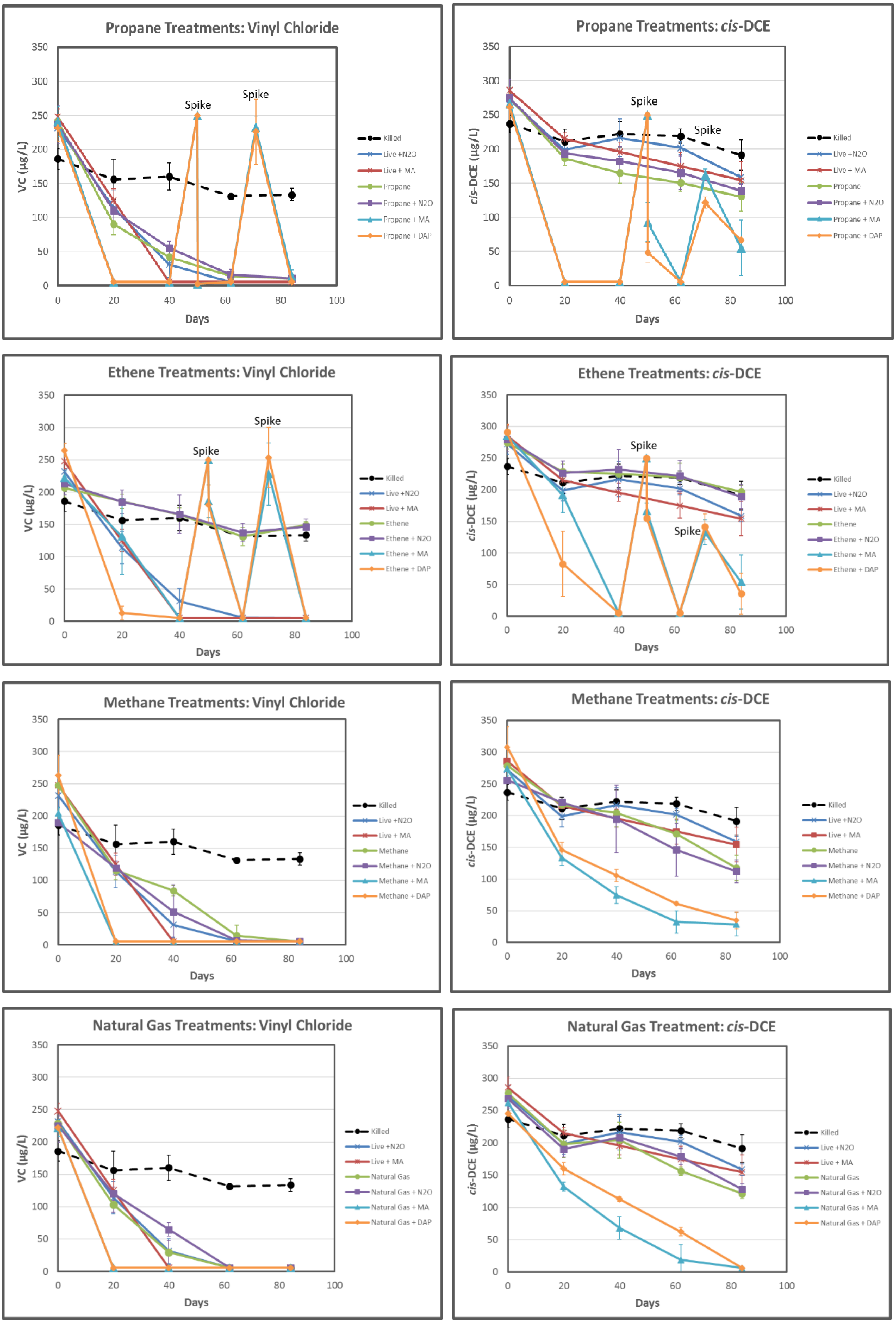
*Killed Controls received 2,000 mg/L mercuric chloride and 0.1% v/v formaldehyde to inhibit microbial activitiy.

The microcosms were spiked to achieve an approximate starting aqueous concentration of 250 µg/L of both *cis*-DCE and VC. Substrate gases, inorganic nutrients, and/or cVOCs were monitored and added to bottles throughout the study as needed, with substrate gas and nutrient additions ending on Day 48. Microcosms were sampled for cVOCs after 24 hours of equilibration (i.e., time zero), and approximately once every 3 weeks during the 12 weeks of testing, yielding 5 time points in total. Graphs summarizing *cis*-DCE and VC data collected from treatments amended with propane, ethene, methane and natural gas (~95% methane) are presented in **Figure 5.8**.

Propane- and ethene-amended treatments showing complete degradation of *cis*-DCE and VC were re-spiked twice during the study. The key results of the microcosm study are as follows:

- Biodegradation of the four primary substrate gases (propane, ethene, methane and natural gas) and *cis*-DCE and VC were slower in treatments that did not include diammonium phosphate (DAP) or the combination of methylamine and TEP, suggesting a nutrient limitation at the site;
- Complete biodegradation of VC was observed in most live treatments, with the fastest degradation rates being observed in those amended with nutrients (other than N_2O);
- Biodegradation of *cis*-DCE was considerably faster in the propane- and ethene-amended treatments that received nutrients (other than N_2O);
- Biodegradation of both VC and *cis*-DCE appear to have been inhibited in treatments that exhibited high dissolved concentrations of the four primary substrate gases;
- Biodegradation of VC and *cis*-DCE wase sustained for more than one month in the absence of amendment addition;
- Methylamine and ammonia were both shown to be effective gaseous sources of N;
- N_2O and TEP was not an effective combination of nutrients for enhancing biodegradation of alkane/alkene gases or target cVOCs, suggesting that N_2O is not a good source of assimilable N at the site; and
- While a source of N is critical for stimulating biological activity, P does not appear to be a limiting nutrient. This suggested that the addition of TEP might not be required during the field demonstration.

While it was evident from the microcosm results that an effective source of N was required to enhance biological activity, the need to add a source of P in conjunction with N was not clear, as P (in the form of DAP and TEP) was added to all the microcosms where primary substrate gases were rapidly depleted. Therefore, a follow-on microcosm study was performed that included treatments with methylamine with and without TEP. As detailed in **Appendix C**, these additional microcosms were prepared and monitored for 169 days, as described for the previous microcosms, except that no cVOCs were added. Propane and oxygen were repeatedly added as they were rapidly consumed during the study. Nutrients were added during setup and at three additional time points. Methylamine was replaced by ammonia in one of the treatments on day 112 of the study to determine if gaseous ammonia might also be an effective source of N for enhancing biological activity. The results of this study showed that while a source of N is critical for stimulating biological activity in materials collected from the site, P does not appear to be a limiting nutrient. The data also indicate that both methylamine and ammonia are effective gaseous sources of N.



Propane Treatments: Vinyl Chloride

Propane Treatments: *cis*-DCE

Ethene Treatments: Vinyl Chloride

Ethene Treatments: *cis*-DCE

Methane Treatments: Vinyl Chloride

Methane Treatments: *cis*-DCE

Natural Gas Treatments: Vinyl Chloride

Natural Gas Treatment: *cis*-DCE

Figure 5.8. Degradation of Vinyl Chloride and *cis*-DCE in Microcosm Treatments Amended with 4 Different Gas Substrates

5.3.2 Batch Kinetic Studies and Modeling

Based on their effectiveness at promoting cVOC degradation during the microcosm studies, propane and ethene were selected for further study. Batch kinetic studies were conducted with these gasses and mixed enrichment cultures derived from select microcosm bottles. These studies 1) examined individual compounds of concern (*cis*-DCE, and VC) and focused on the utilization of the selected substrate gas for biodegradation of these compounds, and 2) assessed inhibition of each gas on cVOC degradation. The information derived from the batch kinetic studies helped inform design (particularly, substrate gas sparging frequency and duration) of the demonstration system to maximize treatment efficacy.

Batch kinetic testing was performed utilizing combinations of substrate (propane or ethene), and *cis*-DCE or VC. These experiments focused on quantifying substrate, *cis*-DCE, and VC biodegradation kinetics. Data from these experiments were used to model maximum degradation rate coefficients and the half saturation parameters for propane, ethene, *cis*-DCE, and VC by propane and ethene-consuming enrichment cultures (**Appendix C**). Michaelis-Menten parameters were estimated using the model and a nonlinear least-square analysis. The estimated model parameters can be used to predict and compare cVOC degradation using propane and ethene. This assumes that enrichments are representative of microbial communities that will be stimulated in the field by addition of the given substrate. **Figure 5.9** shows the degradation of substrate and cVOCs with initial concentrations of 2,000 µg/L substrate, 25 µg/L VC, 150 µg/L *cis*-DCE, with the assumption of no cell growth (at equivalent optical densities), and no separate gas phase. While degradation performance of both the propane and ethene enrichments were generally similar, with effects of substrate inhibition observed over a range of concentrations, this impact was most notable in examining *cis*-DCE degradation. Inhibition of VC was less and consumption of propane itself was quicker in the propane enrichment than the comparable consumption of ethene by the ethene enrichment. This observation, together with overall faster growth of propane enrichments in the laboratory (data not shown), indicated that propane was preferable for implementation at field scale for degradation of *cis*-DCE and VC.

5.4 DESIGN AND LAYOUT OF TECHNOLOGY COMPONENTS

As discussed above, this project entailed cometabolic biosparging using a line of vertical biosparging wells installed perpendicular to groundwater flow across the width of a large, dilute cVOC plume containing *cis*-DCE and VC. Contaminated groundwater was treated as it flowed through a biologically active zone (biobarrier) created by biosparging oxygen, propane, and ammonia gases to stimulate indigenous bacteria capable of cometabolically degrading *cis*-DCE and VC to below MCLs. The biosparging system was designed and constructed to operate completely "off-the-grid" using solar power energy.

The following subsections detail the design, layout, and installation of the various demonstration components. All field activities associated with system installation were conducted using appropriate Level D PPE. Underground utility clearances were obtained for all intrusive site activities, and clearance of all underground utilities was arranged through the appropriate Air Force representatives, airport facility personnel, the Palmetto Utility Protection Service, and local utility companies. Permits to construct all biosparging and monitoring wells were obtained from SCDHEC prior to well installations. APTIM submitted a Notice of Construction (Form 7460-1) to the Federal Aviation Administration (FAA) on February 21, 2019 for the installation of the biosparging system and solar panels, and the FAA provided final approval on May 31, 2019.

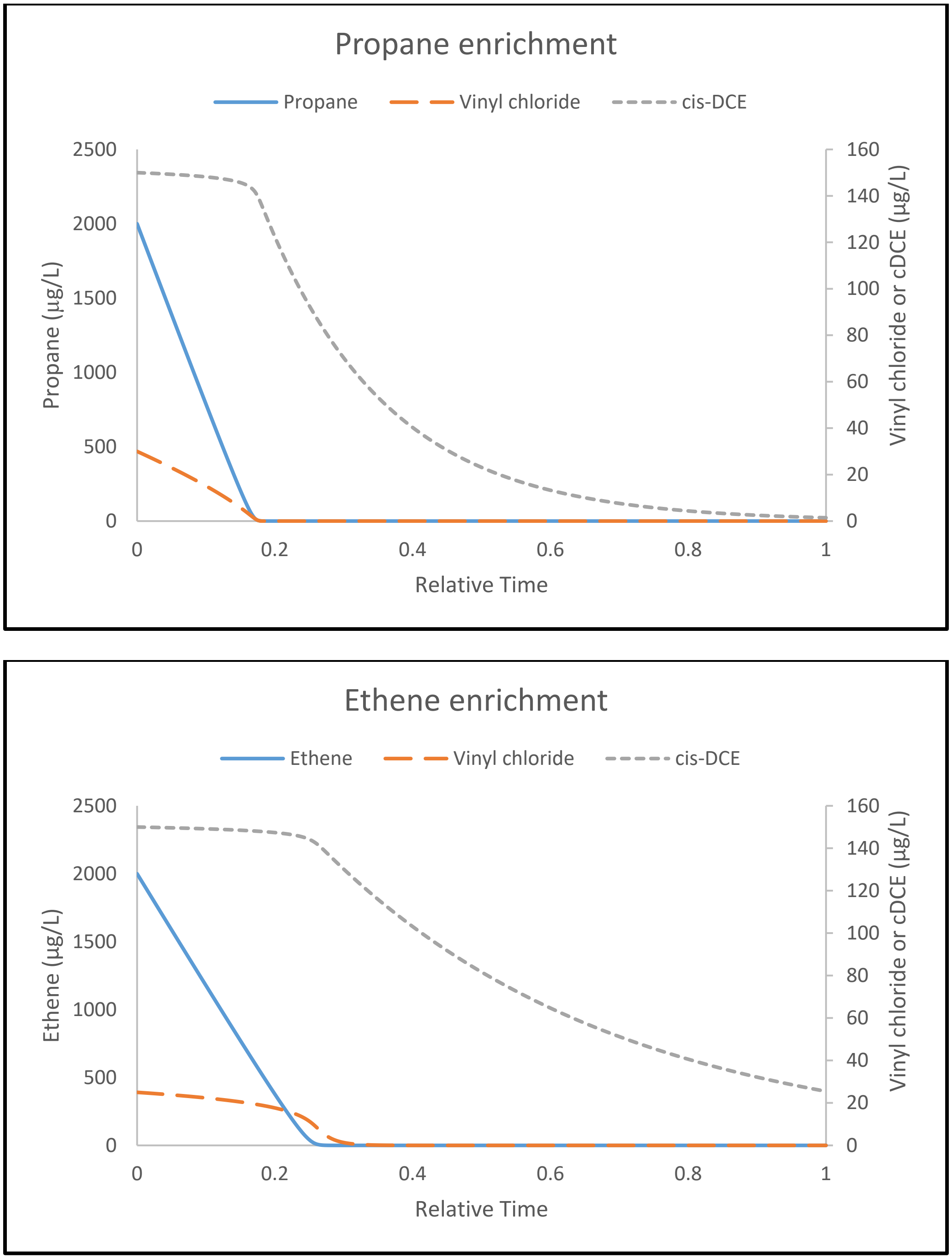


Figure 5.9. Modeled Propane, Ethane, VC and *cis*-DCE Degradation with Time for a Hypothetical Scenario.

The scenario assumes no bacterial growth (with both enrichments at equivalent optical densities), no separate gas phase, and initial concentrations of 2,000 µg/L for propane or ethene, 25 µg/L for VC, and 150 µg/L for cis-DCE.

5.4.1 Demonstration Well Design and Layout

The biosparging well layout installed during the demonstration is provided in **Figure 5.10**. The design included a total of twenty-two vertical biosparging wells (11 deep, 6 intermediate, and 5 shallow) installed across the thickness of the treatment zone (see **Figure 5.11**). The biosparging wells were installed on 20-ft centers for each interval using direct-push drilling methods. Based on sparge testing results (**Section 5.2.1.5**), a biobarrier that is a minimum of 20 ft wide (as shown on **Figure 5.10**) will be created by intermittently sparging at each of the 22 biosparging wells at a sparging rate of 10-15 SCFM. With an estimated linear groundwater seepage velocity of 0.5 ft/day (**Section 4.3**), residence time within the biobarrier was estimated at approximately 40 days. As shown in **Figure 5.8**, degradation of *cis*-DCE and VC to below the level of detection (1.1 µg/L) was observed within 20 days in the microcosms amended with propane and nutrients, with degradation rates increasing as target microbial communities grew within the microcosms. Thus, with a residence time approximately twice that observed for treatment, it was anticipated that the target contaminants would be degraded to below MCLs within the biobarrier.

The performance monitoring well network (**Figure 5.10**) consisted of a total of 27 monitoring wells located within, upgradient and downgradient of the biobarrier as follows:

- Four clusters of discrete interval monitoring wells (four wells per cluster) located 5, 10, 15 and 25 ft downgradient of the line of biosparging wells. These wells were located within and downgradient of the biobarrier, in the approximate center of the thickest portion of the plume. Each of the well clusters were used to monitor three separate intervals across the plume thickness (~15 ft), and one interval above the plume (see cross-section C-C', **Figure 5.12**). Fourteen of these sixteen wells were installed during site characterization activities (**Section 5.2.1.4**). Two additional wells (PMW-0-1 and PMW-0-2) were subsequently installed in this area (**Section 5.4.3**). It should be noted that sparge wells STW-1S and STW-1D installed for sparge testing were renamed as PMW-0-3 and PMW-0-4, respectively;
- One cluster of discrete interval monitoring wells (three wells in the cluster: PMW-1S, PMW-1I and PMW-1D) located ~8 ft upgradient of the line of biosparging wells. These wells were located within the biobarrier, in the approximate center of the thickest portion of the plume, and were used to monitor three intervals across the plume thickness (~15 ft), as shown on cross-section C-C' on **Figure 5.12**;
- One pair of discrete interval monitoring wells (two wells in the cluster: PMW-2I and PMW-2D) located within the biobarrier, ~8 ft downgradient of the line of biosparging wells (**Figure 5.10**). These wells were be located in the southern area of the thickest portion of the plume, and were used to monitor the deep and intermediate intervals of the plume;
- One existing monitoring well (MB-30) located an additional 15 ft downgradient of the above well cluster (downgradient of the biobarrier; as shown on **Figure 5.10**). This well has a 10-ft screen located within the treatment interval;
- Three discrete interval monitoring wells located in the northern area, where the plume is approximately 5 ft thick. Wells PMW-3I and PMW-3D were located approximately 5 ft downgradient of the biosparging wells (**Figure 5.10**), and were used to monitor one interval within the plume and one interval above the plume within the biobarrier. PMW-4D, located downgradient of the biobarrier, was used to monitor the deep interval approximately 15 ft downgradient of the biosparging wells; and

- One pair of discrete interval monitoring wells (BMW-1I and BMW-1D) located approximately 40 ft upgradient of the line of biosparging wells (**Figure 5.10**). These background monitoring wells were located within the approximated center of the plume, outside the influence of the biosparging wells. The well pair was used to monitor the deep and intermediate intervals of the plume, as shown on cross-section C-C' on **Figure 5.12**.

All wells were installed using direct-push technology drilling techniques as discussed below. Installation and development of the 22 biosparging wells and 12 remaining performance monitoring wells was performed between May 30, 2019 and June 6, 2019. Drilling and well construction was performed by a South Carolina-licensed driller and supervised by an APTIM geologist. Upon completion of well installation activities, a Water Well Record (D-1903) was generated and submitted to SCDHEC for each well installed.

Four of the six vapor probes (VP-1 through VP-4) installed during site characterization activities (as shown in **Figure 5.10)** were monitored to assess any potential sparge gas migration into the vadose zone during the demonstration. However, based on the data collected during sparge testing, the impacts of biosparging within the aquifer were not expected to significantly impact the vadose zone (due to formation heterogeneities).

5.4.2 Biosparging Well Installation

As shown on cross-section B-B' (**Figure 5.11**), the vertical biosparging wells were installed on 20-ft centers with screens at three different vertical intervals; two in the Sand and Shell Hash layer, and one below in the Dense Sand layer. Each well was constructed of 1-inch Schedule 40 PVC casing, with a 1.5-ft long pre-packed screen.

Borings for each well were advanced to their pre-determined depth using 3.75-inch OD direct-push rods with an expendable point. The wells were assembled and installed to the target depth through the rods, as shown in **Figure 5.13**. The expendable point was then dislodged, and the rod string slowly retracted, allowing the surrounding formation to collapse until the leading end of the rods was one ft above the top of the well screen. A seal consisting of coated ¼-inch bentonite tablets (Cetco® coated tablets) was installed from the top of the collapsed formation to 11 ft-bgs (approximately 3-5 ft below the water table) as the rod string was retracted further. The extended bentonite seal was used instead of bentonite-cement grout throughout portions of the annular space to eliminate the possibility of grout impacting neighboring well screens (located as close as 3 ft away) and to provide a continuous and competent annular seal. A bentonite-cement grout was then be installed to fill the remaining annular space to within one ft of the ground surface as the remaining rod string was removed. The wells were completed with 10-inch by 15-inch polymer composite flush-mount well vaults set in and surrounded by compacted surface soil.

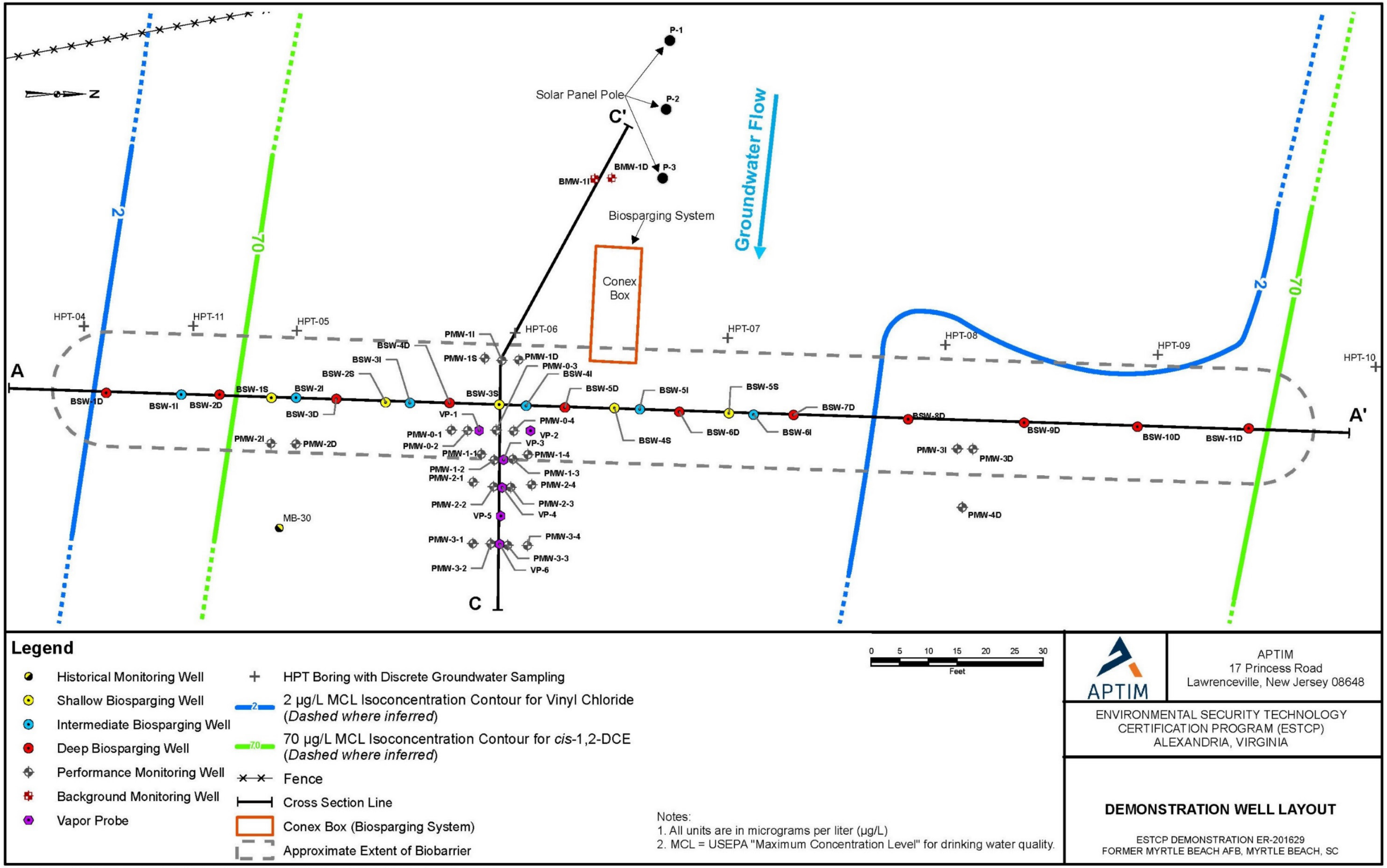


Figure 5.10. Demonstration Biosparging and Performance Monitoring Well Layout

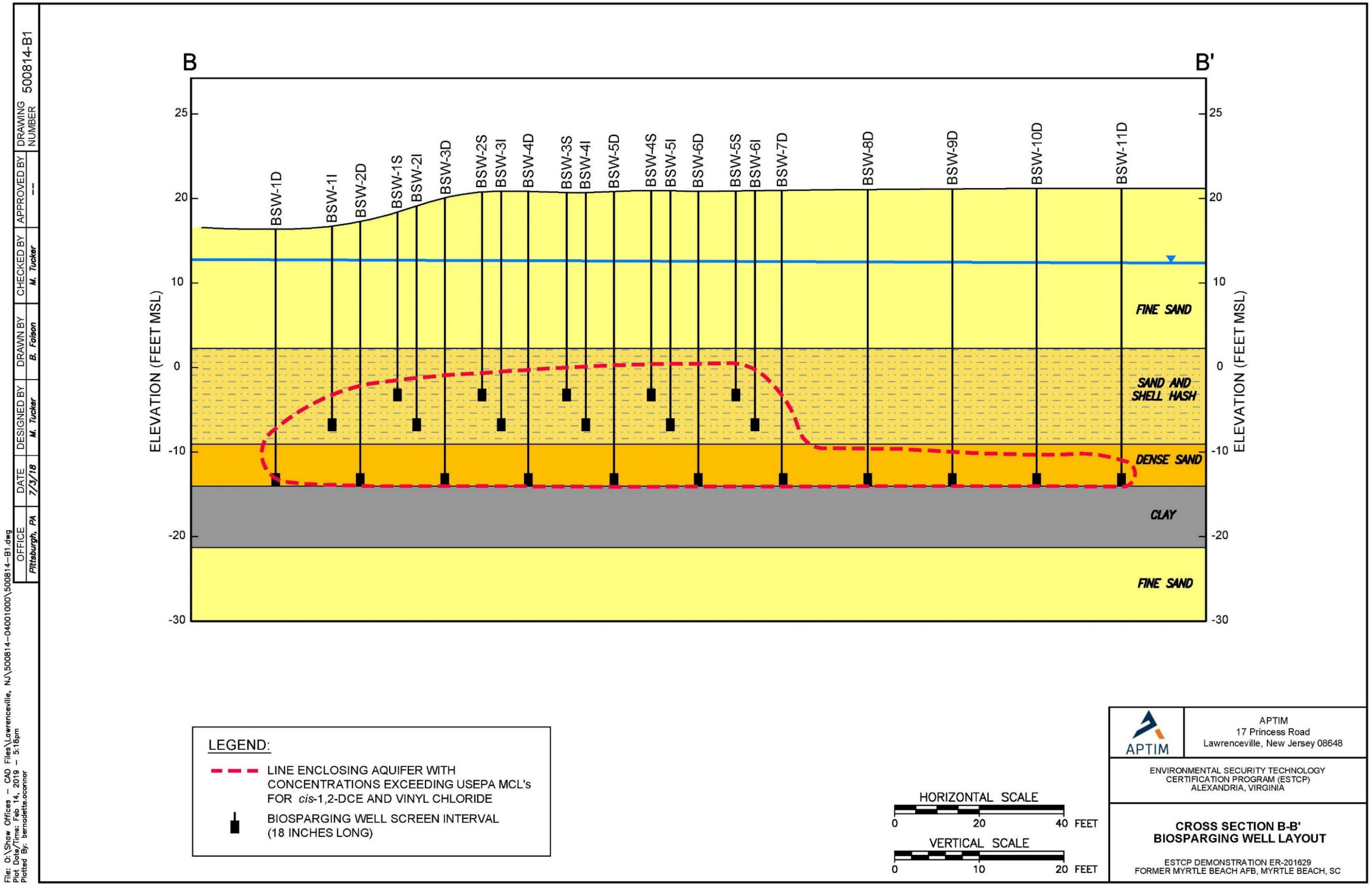


Figure 5.11. Generalized Geologic Cross Section Showing Proposed Biosparging Well Layout

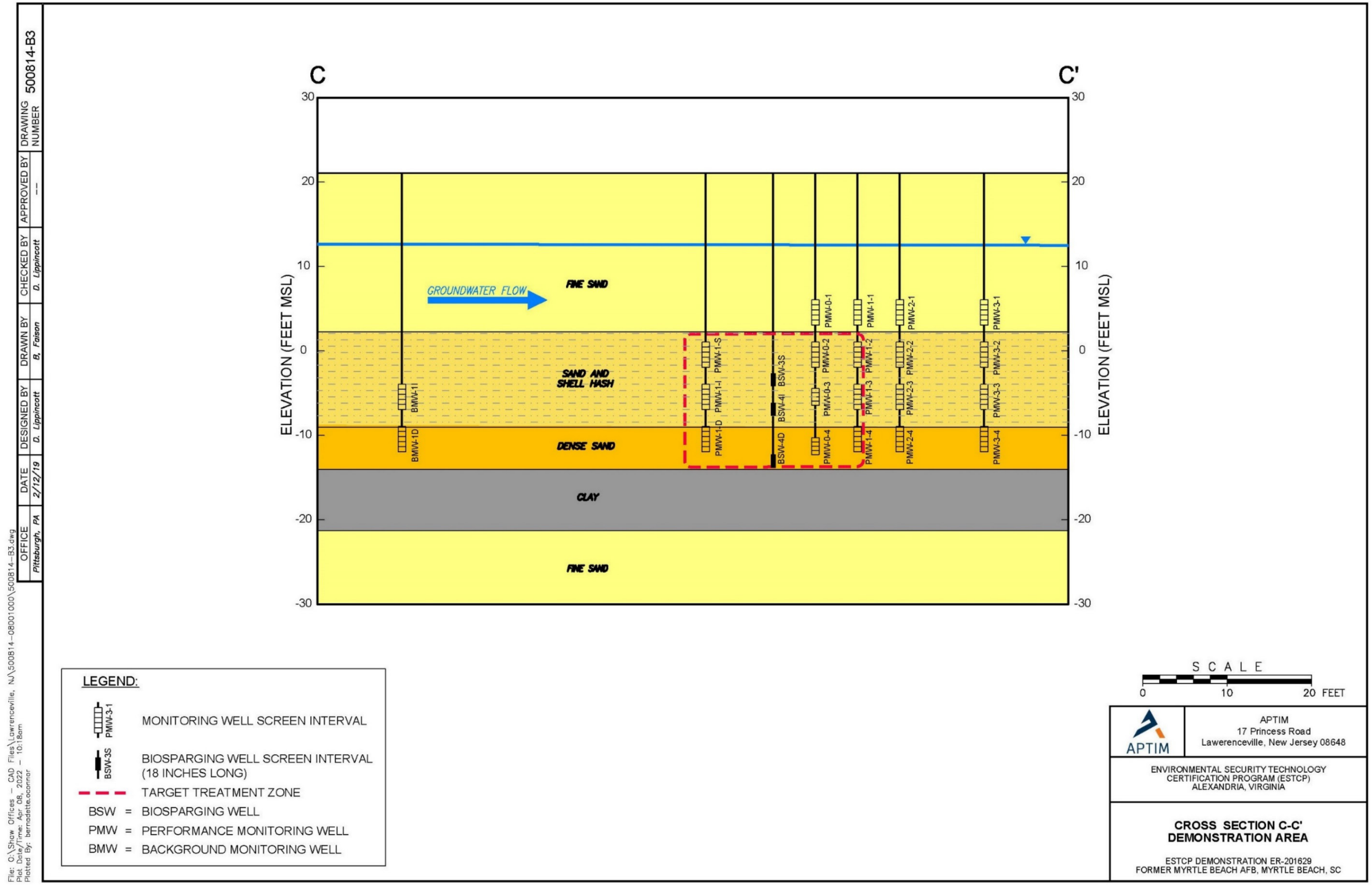


Figure 5.12. Generalized Geologic Cross Section Showing Proposed Demonstration Area

Figure 5.13. Photograph of a Direct-Push Well Installation.

All wells were installed through DPT drilling rods once the target depth was reached.

All wells were surveyed for elevation and Northing/Easting coordinates with respect to an established benchmark by a professional surveyor. **Table 5.5** contains a summary of as-built well construction details, and a typical sparge well construction diagram is presented as **Figure 5.14**. As-built well construction logs are presented in **Appendix B**.

The wells were developed using a peristaltic pump and a surge block, and water was not added to the well to aid in development. Well development was accomplished by surging the well, followed by pumping groundwater until the water was clear and the well was sediment free to the extent practical. Groundwater extracted during well development, and decontamination fluids were containerized in 55-gallon drums and temporarily staged within the demonstration area. The contents of the drums were sampled for waste characterization and subsequent off-site disposal.

Table 5.5. As-Built Well Construction Summary Details

Location ID	Approximate Distance from Sparge Wells (ft)	Well Diameter (in)	Borehole Diameter (in)	Pre-packed Screen Length[1] (ft)	Sump Interval (ft. bgs)	Screen Interval (ft. bgs)	Filter Pack Interval[2] (ft. bgs)	Bentonite Seal Interval[3] (ft. bgs)	Grout Interval[4] (ft. bgs)
Performance Monitoring Wells									
PMW-0-1	5	1.25	3.75	3.0	17.8 - 18.0	14.8 - 17.8	14.0 - 18.0	11.0 - 14.0	0.5 - 11.0
PMW-0-2	5	1.25	3.75	3.0	22.6 - 22.8	19.6 - 22.6	18.0 - 22.8	11.0 - 18.0	0.5 - 11.0
PMW-0-3	5	1.25	3.75	2.0	27.4 - 27.7	25.4 - 27.4	25.0 - 27.7	13.0 - 25.0	1.0 - 13.0
PMW-0-4	5	1.25	3.75	2.0	33.2 - 33.5	31.2 - 33.2	31.0 - 33.5	13.0 - 31.0	1.0 - 13.0
PMW-1-1	10	1.25	3.75	3.0	18.1 - 18.4	15.1 - 18.1	13.0 - 18.4	12.0 - 13.0	1.0 - 12.0
PMW-1-2	10	1.25	3.75	3.0	22.8 - 23.1	19.8 - 22.8	19.0 - 23.1	12.0 - 19.0	1.0 - 12.0
PMW-1-3	10	1.25	3.75	3.0	27.9 - 28.2	24.9 - 27.9	24.0 - 28.2	12.0 - 24.0	1.0 - 12.0
PMW-1-4	10	1.25	3.75	3.0	33.0 - 33.3	30.0 - 33.0	29.0 - 33.3	13.0 - 29.0	1.0 - 13.0
PMW-2-1	15	1.25	3.75	3.0	18.0 - 18.3	15.0 - 18.0	13.0 - 18.3	12.0 - 13.0	1.0 - 12.0
PMW-2-2	15	1.25	3.75	3.0	22.9 - 23.2	19.9 - 22.9	18.0 - 23.2	12.0 - 18.0	1.0 - 12.0
PMW-2-3	15	1.25	3.75	3.0	27.4 - 27.7	24.4 - 27.4	24.0 - 27.7	13.0 - 24.0	1.0 - 13.0
PMW-2-4	15	1.25	3.75	3.0	32.7 - 33.0	29.7 - 32.7	28.7 - 33.0	13.0 - 28.7	1.0 - 13.0
PMW-3-1	25	1.25	3.75	3.0	18.1 - 18.4	15.1 - 18.1	13.0 - 18.4	12.0 - 13.0	1.0 - 12.0
PMW-3-2	25	1.25	3.75	3.0	23.1 - 23.4	20.1 - 23.1	19.0 - 23.4	13.0 - 19.0	1.0 - 13.0
PMW-3-3	25	1.25	3.75	3.0	27.8 - 28.1	24.8 - 27.8	23.8 - 28.1	13.0 - 23.8	1.0 - 13.0
PMW-3-4	25	1.25	3.75	3.0	32.5 - 32.8	29.5 - 32.5	28.5 - 32.8	13.0 - 28.5	1.0 - 13.0
PMW-1S	8	1.25	3.75	3.0	22.4 - 22.6	19.4 - 22.4	18.0 - 22.6	11.0 - 18.0	0.5 - 11.0
PMW-1I	8	1.25	3.75	3.0	27.3 - 27.5	24.3 - 27.3	23.0 - 27.5	11.0 - 23.0	0.5 - 11.0
PMW-1D	8	1.25	3.75	3.0	32.8 - 33.0	29.8 - 32.8	29.0 - 33.0	11.0 - 29.0	0.5 - 11.0
PMW-2I	8	1.25	3.75	3.0	27.7 - 27.9	24.7 - 27.7	23.5 - 27.9	11.0 - 23.5	0.5 - 11.0
PMW-2D	8	1.25	3.75	3.0	33.3 - 33.5	30.3 - 33.3	29.0 - 33.5	11.0 - 29.0	0.5 - 11.0
PMW-3I	5	1.25	3.75	3.0	27.1 - 27.3	24.1 - 27.1	23.0 - 27.3	11.0 - 23.0	0.5 - 11.0
PMW-3D	5	1.25	3.75	3.0	33.9 - 34.1	30.9 - 33.9	30.0 - 34.1	10.5 - 30.0	0.5 - 10.5
PMW-4D	15	1.25	3.75	3.0	33.1 - 33.3	30.1 - 33.1	29.0 - 33.3	11.0 - 29.0	0.5 - 11.0
Background Monitoring Wells									
BMW-1I	40	1.25	3.75	3.0	27.6 - 27.8	24.6 - 27.6	24.0 - 27.8	11.0 - 24.0	0.5 - 11.0
BMW-1D	40	1.25	3.75	3.0	33.6 - 33.8	30.6 - 33.6	29.0 - 33.8	11.0 - 29.0	0.5 - 11.0
Shallow Biosparging Wells									
BSW-1S	NA	1	3.75	1.5	23.4 - 24.6	21.9 - 23.4	20.0 - 24.6	11.0 - 20.0	1.5 - 11.0
BSW-2S	NA	1	3.75	1.5	23.8 - 25.0	22.3 - 23.8	21.0 - 25.0	11.0 - 21.0	1.5 - 11.0
BSW-3S	NA	1	3.75	1.5	23.7 - 24.9	22.2 - 23.7	30.0 - 24.9	11.0 - 30.0	1.5 - 11.0
BSW-4S	NA	1	3.75	1.5	23.3 - 24.5	21.8 - 23.3	30.0 - 24.5	11.0 - 30.0	1.5 - 11.0
BSW-5S	NA	1	3.75	1.5	22.0 - 23.2	20.5 - 22.0	30.0 - 23.2	11.0 - 30.0	1.5 - 11.0
Intermediate Biosparging Wells									
BSW-1I	NA	1	3.75	1.5	26.8 - 28.0	25.3 - 26.8	24.0 - 28.0	11.0 - 24.0	1.5 - 11.0
BSW-2I	NA	1	3.75	1.5	27.5 - 28.7	26.0 - 27.5	25.0 - 28.7	11.0 - 25.0	1.5 - 11.0
BSW-3I	NA	1	3.75	1.5	27.2 - 28.4	25.7 - 27.2	24.5 - 28.4	11.0 - 24.5	1.5 - 11.0
BSW-4I	NA	1	3.75	1.5	27.9 - 29.1	26.4 - 27.9	25.0 - 29.1	11.0 - 25.0	1.5 - 11.0
BSW-5I	NA	1	3.75	1.5	26.9 - 28.1	25.4 - 26.9	24.0 - 28.1	11.0 - 24.0	1.5 - 11.0
BSW-6I	NA	1	3.75	1.5	26.8 - 28.0	25.3 - 26.8	24.0 - 28.0	11.0 - 24.0	1.5 - 11.0
Deep Biosparging Wells									
BSW-1D	NA	1	3.75	1.5	30.9 - 32.1	29.4 - 30.9	28.0 - 32.1	11.0 - 28.0	1.5 - 11.0
BSW-2D	NA	1	3.75	1.5	31.6 - 32.8	30.1 - 31.6	29.0 - 32.8	11.0 - 29.0	1.5 - 11.0
BSW-3D	NA	1	3.75	1.5	33.7 - 34.9	32.2 - 33.7	31.0 - 34.9	12.0 - 31.0	1.5 - 12.0
BSW-4D	NA	1	3.75	1.5	33.5 - 34.7	32.0 - 33.5	31.0 - 34.7	12.0 - 31.0	1.5 - 12.0
BSW-5D	NA	1	3.75	1.5	34.2 - 35.4	32.7 - 34.2	14.0 - 35.4	11.0 - 14.0	1.5 - 11.0
BSW-6D	NA	1	3.75	1.5	32.8 - 34.0	31.3 - 32.8	30.0 - 34.0	11.0 - 30.0	1.5 - 11.0
BSW-7D	NA	1	3.75	1.5	33.0 - 34.2	31.5 - 33.0	30.0 - 34.2	11.0 - 30.0	1.5 - 11.0
BSW-8D	NA	1	3.75	1.5	32.6 - 33.8	31.1 - 32.6	30.0 - 33.8	11.0 - 30.0	1.5 - 11.0
BSW-9D	NA	1	3.75	1.5	32.5 - 33.7	31.0 - 32.5	29.0 - 33.7	12.0 - 29.0	1.5 - 12.0
BSW-10D	NA	1	3.75	1.5	33.0 - 34.2	31.5 - 33.0	30.0 - 34.2	11.0 - 30.0	1.5 - 11.0
BSW-11D	NA	1	3.75	1.5	32.8 - 34.0	31.3 - 32.8	30.0 - 34.0	11.0 - 30.0	1.5 - 11.0
Vapor Probes									
VP-1	5	0.75	4.0	0.5	3.8 - 3.9	3.2 - 3.8	3.0 - 3.9	2.0 - 3.0	1.0 - 2.0
VP-2	5	0.75	4.0	0.5	3.8 - 3.9	3.2 - 3.8	3.0 - 3.9	2.0 - 3.0	1.0 - 2.0
VP-3	10	0.75	4.0	0.5	3.8 - 3.9	3.2 - 3.8	3.0 - 3.9	2.0 - 3.0	1.0 - 2.0
VP-4	15	0.75	4.0	0.5	3.8 - 3.9	3.2 - 3.8	3.0 - 3.9	2.0 - 3.0	1.0 - 2.0
VP-5	20	0.75	4.0	0.5	3.8 - 3.9	3.2 - 3.8	3.0 - 3.9	2.0 - 3.0	1.0 - 2.0
VP-6	25	0.75	4.0	0.5	3.8 - 3.9	3.2 - 3.8	3.0 - 3.9	2.0 - 3.0	1.0 - 2.0

Notes:

[1] Vapor probe screens are Sch. 40 PVC slotted screen, not pre-packed screens.

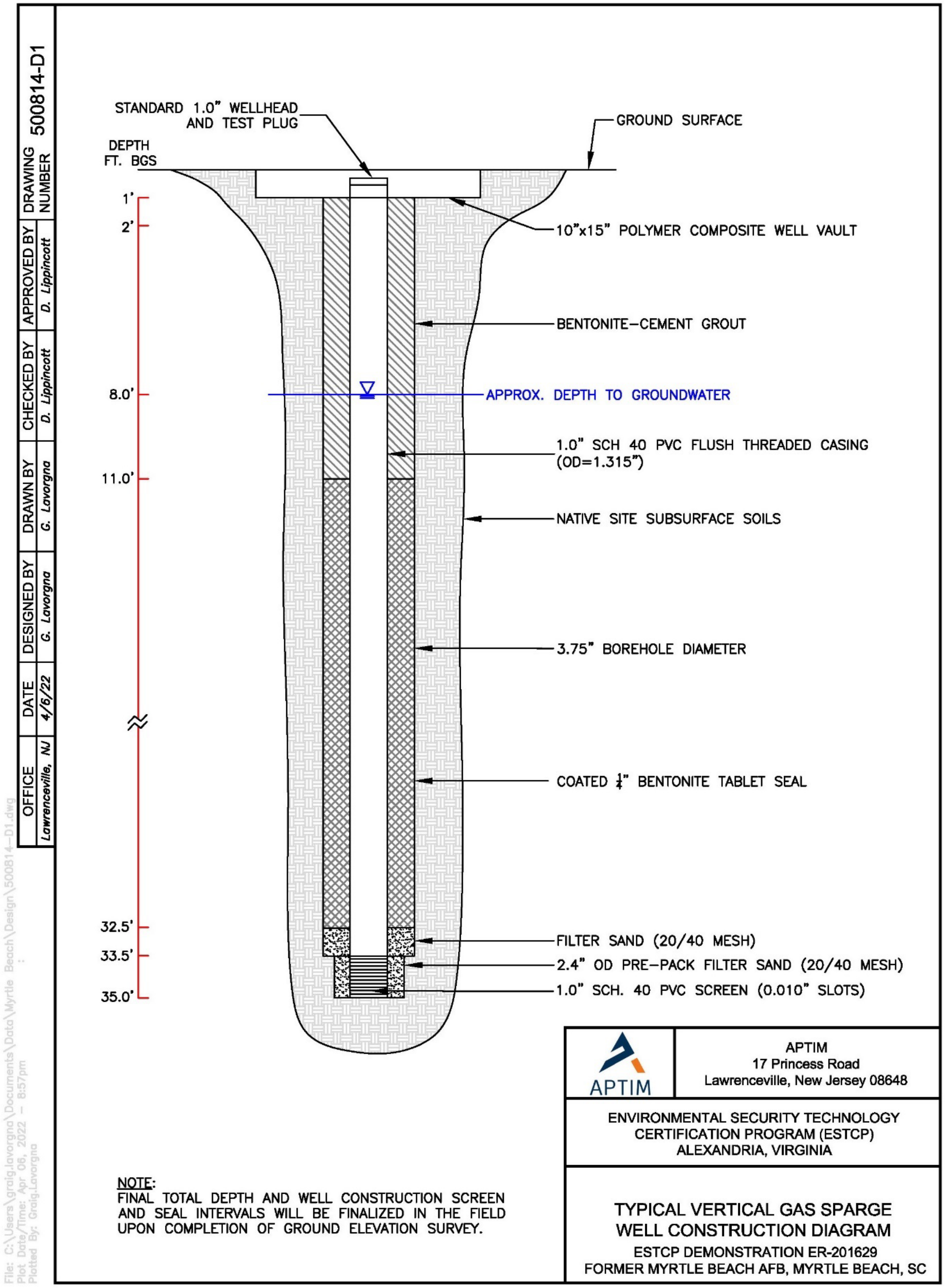
[2] Filter pack interval includes pre-packed screen and formation material (sand) that was left to collapsed as the direct-push rods were retracted.

[3] Bentonite seal consists of 1/4" coated bentonite tablets installed to ~11' to 13' bgs (approximately 5' below the water table).

[4] Grout composed of cement bentonite grout, installed from the top of the bentonite seal to within 0.5 to 1.5' of the ground surface.

ft = feet

bgs = below ground surface



OFFICE	DATE	DESIGNED BY	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
Lawrenceville, NJ	*4/6/22*	*G. Lavorgna*	*G. Lavorgna*	*D. Lippincott*	*D. Lippincott*	500814-D1

NOTE:
FINAL TOTAL DEPTH AND WELL CONSTRUCTION SCREEN AND SEAL INTERVALS WILL BE FINALIZED IN THE FIELD UPON COMPLETION OF GROUND ELEVATION SURVEY.

APTIM
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ENVIRONMENTAL SECURITY TECHNOLOGY
CERTIFICATION PROGRAM (ESTCP)
ALEXANDRIA, VIRGINIA

TYPICAL VERTICAL GAS SPARGE
WELL CONSTRUCTION DIAGRAM
ESTCP DEMONSTRATION ER-201629
FORMER MYRTLE BEACH AFB, MYRTLE BEACH, SC

Figure 5.14. Typical Biosparging Well Construction Diagram

5.4.3 Performance Monitoring Well Installation

The discrete interval PMW wells and background monitoring wells (BMWs) were constructed using the same materials and installation techniques as the sparge wells described in the previous section, except the well casings ID were 1.25 inches, and the pre-packed screen lengths were 3-ft. As discussed in **Section 5.3.1**, and shown on **Figure 5.10**, the discrete-interval monitoring wells were designed to be grouped in clusters, which allowed for the monitoring of up to four discrete vertical aquifer intervals at each cluster location.

The vertical and horizontal distribution of these wells was designed for the assessment of gas distribution and groundwater quality, and spanned the vertical extent of portions of the plume identified during the site characterization direct-push investigation. Additionally, several wells were screened above the top of the plume to monitor potential impacts of sparging on the shallow, uncontaminated portion of the aquifer.

There was a minimum of 2 ft of vertical spacing between screen intervals at each well cluster, and the bottom of the deepest well was installed approximately 1 ft above the bottom of the defined plume. The wells were completed with 8-inch diameter flush-mount well vaults set in concrete. Upon completion, locking caps and properly labeled identification plates were installed on each well. All wells were surveyed for elevation and Northing/Easting coordinates with respect to an established benchmark by a professional surveyor. A summary of as-built well construction details is provided in **Table 5.5**, and a typical monitoring well construction diagram is presented as **Figure 5.15**. As-built well construction logs are presented in **Appendix B**. Well development and waste characterization and disposal were performed as described in **Section 5.4.2**.

5.4.4 Biosparging System Design

The biosparging system was designed to operate completely “off-the-grid” using solar energy and pressure from gas cylinders to supply oxygen, propane, and ammonia gases to each of the 22 biosparging wells. A piping and instrumentation diagram (P&ID) for the system is presented as **Figure 5.16**, and a system enclosure layout drawing is included as **Figure 5.17**. The biosparging system was controlled automatically by a supervisory control and data acquisition (SCADA) system connected to a programmable logic controller (PLC) panel that allowed both on-site and remote system monitoring of system operational parameters (gas flows, pressures, injection durations and frequencies), operational set-point control, and alarm notification and acknowledgment. Flow of each of the four gases was controlled by individual automated solenoid valves and gas-specific digital mass flow controllers that automatically adjusted to maintain the specified flow. Each biosparging well had an individually controlled solenoid valve to allow sparging one well at a time. The gases were pulsed into the aquifer via the biosparging wells under an optimized flow rate and frequency designed to minimize off-gassing into the vadose zone, while maintaining target dissolved concentrations of the gases to facilitate biomass growth, and ultimately cVOC treatment.

For safety reasons, the oxygen was sparged independently of the propane and ammonia gases, with compressed nitrogen gas used for both flushing the system between sparging cycles, and as a carrier gas for the propane and ammonia. The use of nitrogen as a carrier gas was designed to maximize the desired sparging area of influence at each well, without delivering excessive (significantly higher than solubility) amounts of the gaseous amendments during a sparge cycle.

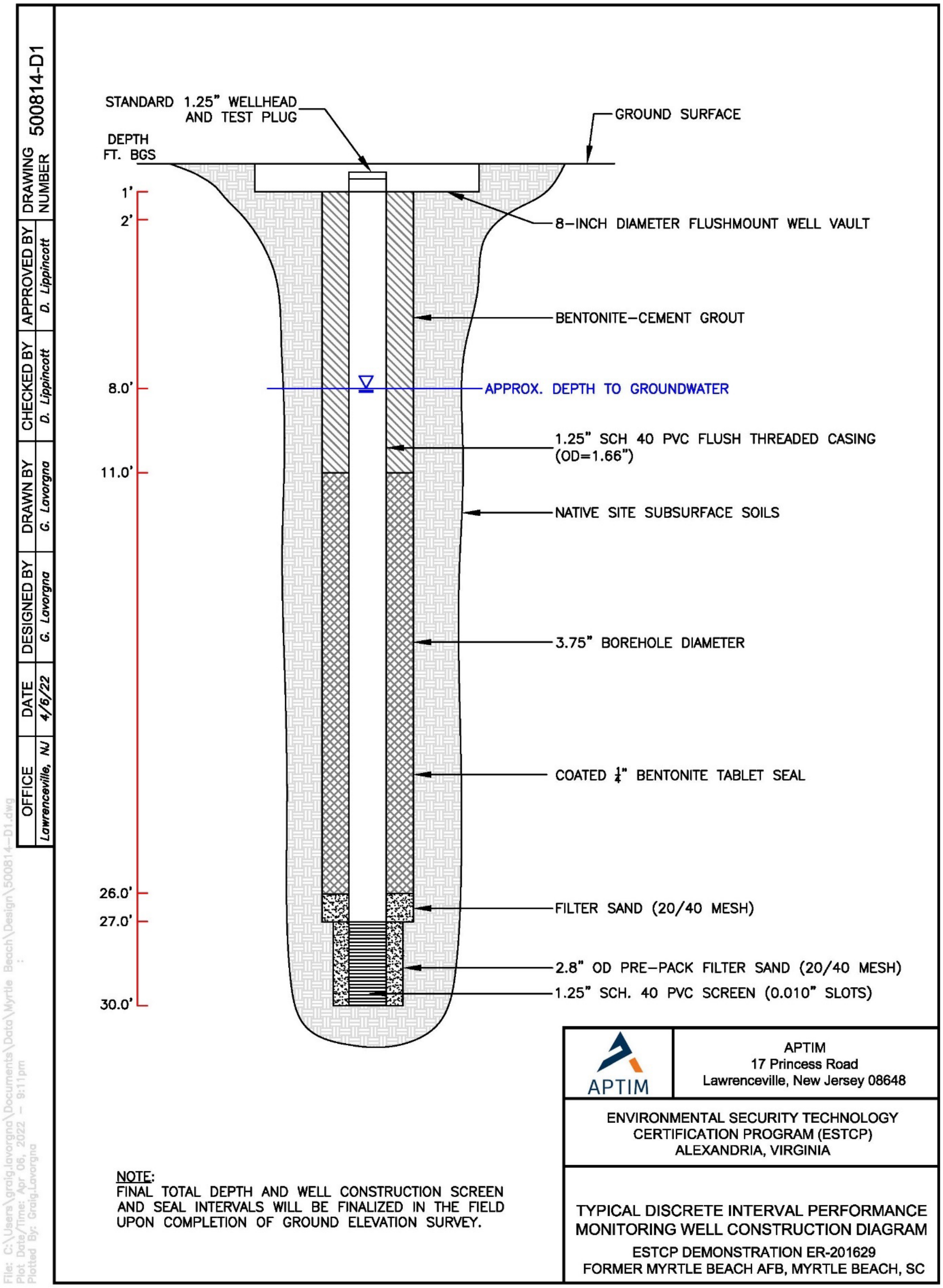


Figure 5.15. Typical Discrete Interval Monitoring Well Construction Diagram

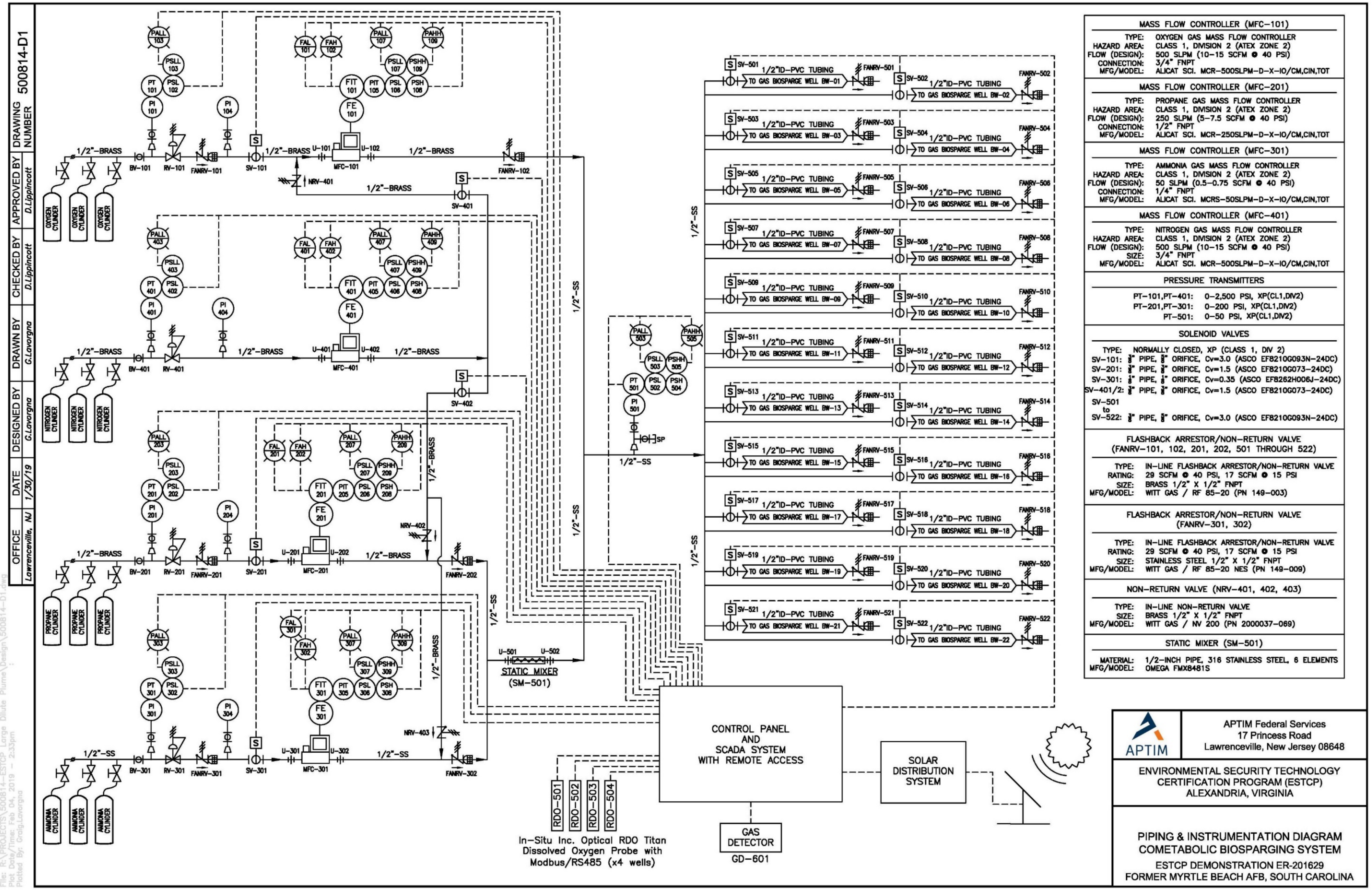
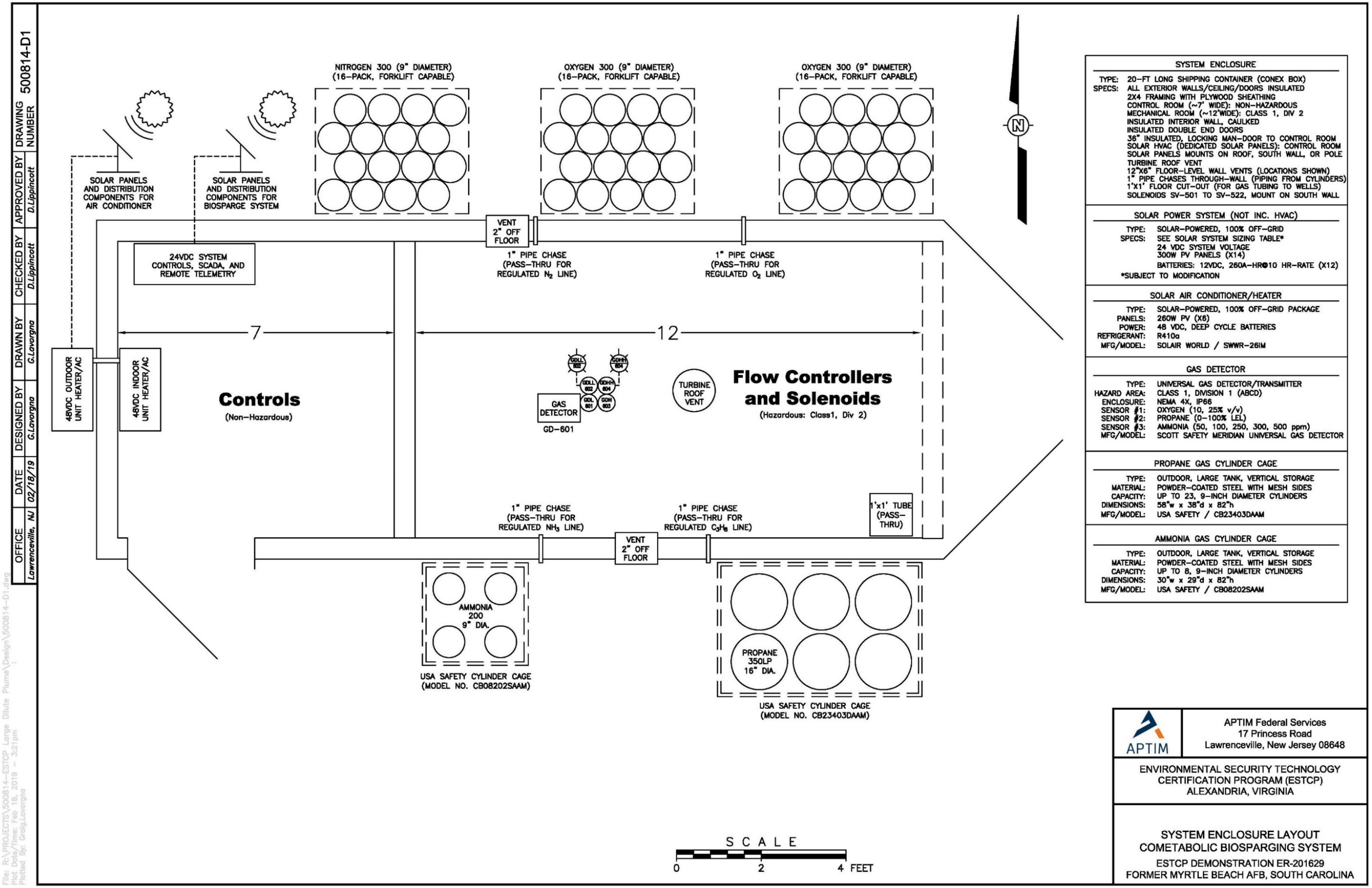


Figure 5.16. Biosparging System Piping and Instrumentation Diagram



SYSTEM ENCLOSURE

TYPE: 20–FT LONG SHIPPING CONTAINER (CONEX BOX)
SPECS: ALL EXTERIOR WALLS/CEILING/DOORS INSULATED
2X4 FRAMING WITH PLYWOOD SHEATHING
CONTROL ROOM (~7' WIDE): NON–HAZARDOUS
MECHANICAL ROOM (~12'WIDE): CLASS 1, DIV 2
INSULATED INTERIOR WALL, CAULKED
INSULATED DOUBLE END DOORS
36" INSULATED, LOCKING MAN–DOOR TO CONTROL ROOM
SOLAR HVAC (DEDICATED SOLAR PANELS): CONTROL ROOM
SOLAR PANELS MOUNTS ON ROOF, SOUTH WALL, OR POLE
TURBINE ROOF VENT
12"X6" FLOOR–LEVEL WALL VENTS (LOCATIONS SHOWN)
1" PIPE CHASES THROUGH–WALL (PIPING FROM CYLINDERS)
1'X1' FLOOR CUT–OUT (FOR GAS TUBING TO WELLS)
SOLENOIDS SV–501 TO SV–522, MOUNT ON SOUTH WALL

SOLAR POWER SYSTEM (NOT INC. HVAC)

TYPE: SOLAR–POWERED, 100% OFF–GRID
SPECS: SEE SOLAR SYSTEM SIZING TABLE*
24 VDC SYSTEM VOLTAGE
300W PV PANELS (X14)
BATTERIES: 12VDC, 260A–HR@10 HR–RATE (X12)
*SUBJECT TO MODIFICATION

SOLAR AIR CONDITIONER/HEATER

TYPE: SOLAR–POWERED, 100% OFF–GRID PACKAGE
PANELS: 260W PV (X6)
POWER: 48 VDC, DEEP CYCLE BATTERIES
REFRIGERANT: R410a
MFG/MODEL: SOLAIR WORLD / SWWR–26IM

GAS DETECTOR

TYPE: UNIVERSAL GAS DETECTOR/TRANSMITTER
HAZARD AREA: CLASS 1, DIVISION 1 (ABCD)
ENCLOSURE: NEMA 4X, IP66
SENSOR #1: OXYGEN (10, 25% v/v)
SENSOR #2: PROPANE (0–100% LEL)
SENSOR #3: AMMONIA (50, 100, 250, 300, 500 ppm)
MFG/MODEL: SCOTT SAFETY MERIDIAN UNIVERSAL GAS DETECTOR

PROPANE GAS CYLINDER CAGE

TYPE: OUTDOOR, LARGE TANK, VERTICAL STORAGE
MATERIAL: POWDER–COATED STEEL WITH MESH SIDES
CAPACITY: UP TO 23, 9–INCH DIAMETER CYLINDERS
DIMENSIONS: 58"w x 38"d x 82"h
MFG/MODEL: USA SAFETY / CB23403DAAM

AMMONIA GAS CYLINDER CAGE

TYPE: OUTDOOR, LARGE TANK, VERTICAL STORAGE
MATERIAL: POWDER–COATED STEEL WITH MESH SIDES
CAPACITY: UP TO 8, 9–INCH DIAMETER CYLINDERS
DIMENSIONS: 30"w x 29"d x 82"h
MFG/MODEL: USA SAFETY / CB08202SAAM

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Lawrenceville, NJ	*02/18/19*	*G.Lavorgna*	*G.Lavorgna*	*D.Lippincott*	*D.Lippincott*	500814-D1

APTIM Federal Services
17 Princess Road
Lawrenceville, New Jersey 08648

ENVIRONMENTAL SECURITY TECHNOLOGY
CERTIFICATION PROGRAM (ESTCP)
ALEXANDRIA, VIRGINIA

SYSTEM ENCLOSURE LAYOUT
COMETABOLIC BIOSPARGING SYSTEM
ESTCP DEMONSTRATION ER-201629
FORMER MYRTLE BEACH AFB, SOUTH CAROLINA

Figure 5.17. Biosparging System Enclosure Layout

As presented in **Figure 5.17**, the biosparging system components were housed within a 20-ft long Conex box. The box had a partition wall separating the enclosure into two spaces. The smaller of the two spaces was the system control room, which was rated as a non-hazardous atmosphere, and housed the PLC/SCADA system with integrated computer, electrical control panel, solar power distribution systems, and a combination air conditioner/heater. The larger space, which included gas piping/fittings, mass flow controllers, well control solenoid valves and other system process components, was rated as a Class 1, Division 2 atmosphere, due to the presence of flammable sparge gases flowing through the piping in this portion of the enclosure. All electrical components and connections in this portion of the enclosure were intrinsically safe to meet the hazardous atmosphere classification. This space was monitored with three separate gas detectors, which continuously measured oxygen, propane, and ammonia levels within the enclosure, and had the ability to shut-down the system and notify appropriate personnel in the case of an alarm condition. A cellular-based remote telemetry system was incorporated into the SCADA system, to allow remote control and monitoring of the system, as well as alarm condition call-outs when needed.

As mentioned, this "off-the-grid" system was powered by solar energy, with two separate solar power distribution systems incorporated into the design. The first was a 24-volt (V) direct current (DC) system which powered the PLC/SCADA system and associated system process control components (solenoid valves, mass flow controllers, gas detectors, etc.). Eight 310-watt solar panels, securely mounted on two, 5-inch diameter galvanized steel pipes set vertically in concrete near the Conex box, were utilized to charge eight 6V, 220 ampere hour (Ah) batteries for this system. The orientation of the solar panels and Conex box at the site, as well as the installation angle of the solar panels, was selected to maximize year-round sun exposure. The orientation of the panels was due south, while the installation angle varied from between approximately 10 degrees (°) from horizontal in the summer to approximately 50° in the winter. The second solar power system was rated at 48V DC and was used to power the control room's air conditioner/heater unit. Three 280-watt solar panels, mounted on a third 5-inch diameter galvanized pipe set vertically in concrete near the Conex box, charged one 48V, 69 Ah battery. The reason for utilizing two separate solar power systems was to ensure that if the air conditioner/heater potentially drained its battery bank, it will not shut-down the SCADA/control system and lose system operability.

The biosparging system relied on the regulated cylinder pressures of each gas to inject into the subsurface (no blowers/compressors). As shown in **Figure 5.17**, compressed oxygen, compressed nitrogen, liquid propane and liquid ammonia gas cylinders were all be stored outside of the system enclosure. The liquid ammonia and propane cylinders were housed in locked cylinder cages, to keep them securely staged and inaccessible to non-authorized personnel. The oxygen and nitrogen cylinders were delivered to the site in 16-packs, and stored on one side of the enclosure, while the propane and ammonia were stored on the opposite side for safety. The propane and ammonia cylinders were stored on the south side of the enclosure to allow the sun to warm the cylinders and increase the available gas delivery pressure in the winter months. These cylinders were wrapped with geotextile fabric in the summer months to keep them from overheating in the direct sunlight. The cylinders were "ganged" together with manifolds and equipped with regulators to provide the appropriate delivery pressures and flows.

As presented on **Figure 5.16**, flow of each of the four gases was controlled by individual automated solenoid valves and gas-specific digital mass flow controllers. Each mass flow controller had an integrated valve that automatically adjusted to maintain a specified flow entered by the operator on the SCADA system control screen. Pressure and flow indicators and transmitters were installed throughout the system to monitor system operational conditions and trigger alarms or shut-down the system, if necessary. Each biosparging well had an individually controlled solenoid valve within the Conex box to allow sparging one well at a time. ¾-inch ID by 1-inch OD braided PVC tubing connected each of the 22 well solenoid valves to the corresponding well head. Tubing runs exited the Conex box through a 1-ft by 1-ft access port in the floor (see **Figure 5.17**) and were run underground in a trench to the appropriate well head. As shown on the P&ID (**Figure 5.16**), flame arrestors/non-return valves were incorporated into the system at each of the 22 biosparging wellheads and upstream near the gas cylinders and mass flow controllers to protect the system from potential flashbacks and stop the unwanted backflow of gases.

Dedicated RDO probes installed in four performance monitoring wells (PMW-0-3, PMW-0-4, PMW-1-3 and PMW-1-4) were used to collect real-time DO data within the biobarrier. These wells were all screened within the 15' thick treatment zone (**Figure 5.12**) and located either 5 or 10 ft downgradient of the line of biosparging wells (**Figure 5.11**). The DO sensors were connected to the biosparging system control panel, allowing for viewing and continuous logging of DO concentrations at these wells during and between sparging cycles. These data were critical in determining the frequency and duration of oxygen sparging pulses to maintain DO concentrations in the biobarrier above the target concentration of 3.0 mg/L (**Section 3.2**).

5.4.5 Biosparging System Fabrication & Installation

The biosparging system enclosure, including all the associated process piping, fittings, mass flow controllers, pressure transmitters, solenoid valves, SCADA system and controls, safety components and solar power distribution systems, was procured and fabricated off-site by Calcon Systems Inc. (Calcon; San Ramon, CA), a subcontractor to APTIM. Calcon had the system enclosure delivered to the site on a flatbed truck on July 2, 2019 (**Figure 5.18**), where APTIM personnel offloaded the enclosure via forklift and placed the unit on leveled lengths of 6" x 6" pressure-treated lumber at the demonstration site (**Figure 5.19**).

Installation and initial shake-down of the biosparging system was performed between July 8 and July 20, 2019. During system installation, APTIM personnel excavated shallow (10 to 12-inch deep) trenches between the enclosure and the line of biosparging wells using a walk-behind trencher (**Figure 5.20**). Custom well heads that included a pressure gauge and flashback arrestors were then installed on each of the 22 biosparging wells (**Figure 5.21**). Reinforced sparge gas tubing was installed within the trenches (**Figure 5.22**) and tubing connections were made between the individual biosparging well solenoid valves (**Figure 5.23**) in the system enclosure and the well heads (**Figure 5.21**). Once all of the tubing connections were complete, the trenches were backfilled using the excavated soil.

APTIM procured and installed gas cylinders, cylinder cages and gas manifolds/regulators. As shown in **Figure 5.24**, the liquid ammonia and liquid propane cylinders were stored outside in locked, steel cylinder cages on the south side of the system enclosure. The compressed oxygen and compressed nitrogen cylinders were delivered to the site in 16-packs and stored on opposite side of the enclosure for safety (**Figure 5.25**).

Figure 5.18. Photograph of the Biosparging System Enclosure Delivery.

The 20' x 8' Conex box containing the biosparging system was delivered to the site on a flatbed truck.

Figure 5.19. Photograph of the Biosparging System Enclosure Placed On-Site

Figure 5.20. Photograph of Trenching Activities.

A walk-behind trencher was used to create shallow trenches between the biosparging wells and the biosparging system enclosure.

Figure 5.21. Photograph of Biosparging Well Head Assembly.

The custom well heads included a pressure gauge and a flashback arrestor. Each of the 22 well heads were connected to the biosparging system using reinforced gas tubing.

Figure 5.22. Photograph of Gas Tubing Installation.

Reinforced gas tubing was installed within the trenches and into the system enclosure through an access port in the floor.

Figure 5.23. Photograph of Tubing Connections to the Biosparging System.

Reinforced gas tubing was connected to the gas distribution manifold system within the enclosure. The manifold system consisted of individual solenoid valves to control flow to the 22 biosparging wells.

Figure 5.24. Photograph of Propane and Ammonia Gas Storage.

Liquified propane and liquified ammonia were stored in steel cages on the south side of the enclosure. The cylinders were "ganged" together with manifolds and equipped with regulators to provide the appropriate delivery pressures and flows.

Figure 5.25. Photograph of Oxygen and Nitrogen Gas Storage.

Compressed oxygen and compressed nitrogen were delivered to the site in 16-packs and stored on the north side of the enclosure.

APTIM personnel worked with the Calcon engineer to install the solar panels and make all the necessary electrical connections for the off-the-grid solar power system. As detailed in **Section 5.4.4**, two separate solar power distribution systems were incorporated into the design. The first was a 24V DC system consisting of eight 310-watt solar panels (**Figure 5.26**) and eight 6V, 220 Ah batteries (**Figure 5.27**) that powered the PLC/SCADA system and associated system process control components. The second was a 48V DC system consisting of three 280-watt solar panels (**Figure 5.26**) and one 48V, 69 Ah battery (**Figure 5.27**) that powered the control room's air conditioner/heater unit. The Calcon engineer also made the final control wire connections for four down-well optical RDO probes which were installed in wells PMW-0-3, PMW-0-4, PMW-1-3 and PMW-1-4. All electrical and control wiring was installed within dedicated conduit in shallow trenches.

A photograph of the gas distribution system is provided in **Figure 5.28**. This system included a series of automated solenoid valves and gas-specific digital mass flow controllers to measure and direct flow of the four gases to the gas distribution manifold system (**Figure 5.23**), which directed the gases to the biosparging wells. Flashback arrestors were installed throughout the gas distribution system to protect from potential flashbacks and stop the unwanted backflow of gases.

As detailed in **Section 5.4.4**, the biosparging system was controlled automatically using a SCADA system on a laptop computer, which was connected to the system PLC. A photograph of the PLC panel is provided in **Figure 5.29**, and a screenshot of the system interface screen is provided in **Figure 5.30**. A photograph of the completed system is provided in **Figure 5.31**.

Upon completion of the biosparging system installation activities, the Calcon engineer assisted APTIM with system shake-down and startup activities, as detailed in **Section 5.5.2**. During shake-down, it was discovered that there were numerous leaks in the aboveground biosparging system piping. The leaks appeared to have been primarily the result of pipe fittings not sufficiently threaded together. The leaks within the high-pressure oxygen and nitrogen delivery portions of the system were repaired by APTIM immediately, to allow for startup of oxygen sparging and nitrogen flushing. Leaks at the gas distribution manifold piping/fittings were subsequently detected during oxygen and nitrogen sparging. While the leaks were numerous, they were minor, located within the low-pressure portion of the system, and would occur only during sparging cycles. It was determined that the oxygen sparging and nitrogen flushing could temporarily be conducted in a safe manner while APTIM personnel were on-site, until replacement parts were ordered and Calcon personnel returned to the site and made the necessary repairs. The remaining piping (which included the high-pressure propane and ammonia delivery portions of the system) was tested and repaired, and a complete rebuild of the gas distribution manifold system was performed by both APTIM and Calcon personnel over the next several weeks.

Figure 5.26. Photograph of the Two Solar Panel Arrays.

The eight 310-watt solar panels on the right charged the 24V system, and the three 280-watt solar panels on the left charged the 48V system.

Figure 5.27. Photograph of the 24V and 48V Solar Power Battery Systems.

The 24V power storage system consisted and eight 6V, 220 Ah batteries that powered the PLC/SCADA system and associated system process control components. The 48V power storage system consisted of one 48V, 69 Ah battery that powered the control room's air conditioner/heater unit.

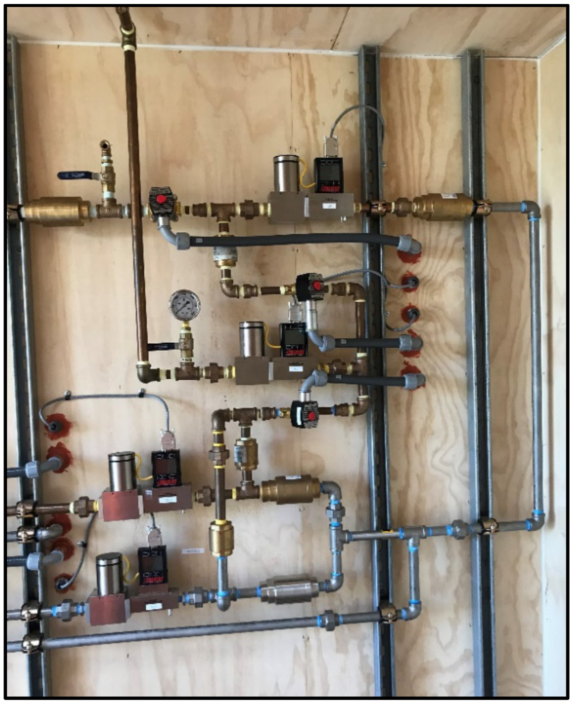


Figure 5.28. Photograph of the Gas Distribution System.

The four gases were directed to the gas distribution manifold system (Figure 5.23) using a series of automated solenoid valves and gas-specific digital mass flow controllers. Flashback arrestors were installed throughout the system.

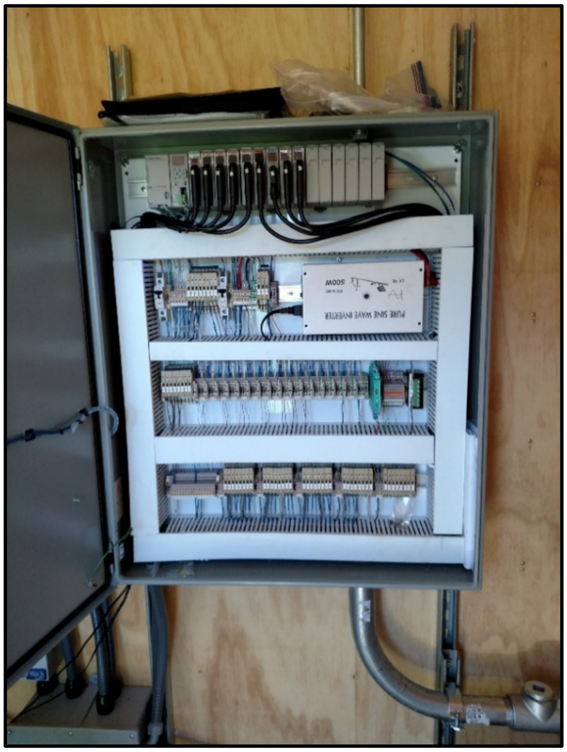
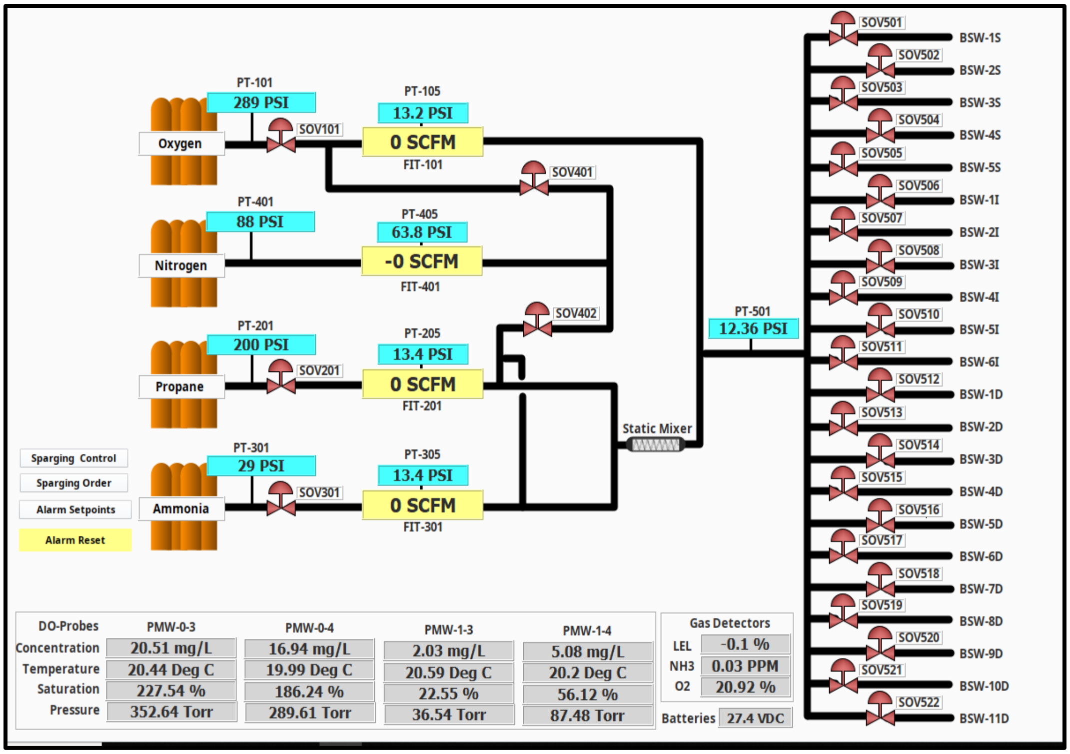


Figure 5.29. Photograph of the PLC Panel



DO-Probes	PMW-0-3	PMW-0-4	PMW-1-3	PMW-1-4
Concentration	20.51 mg/L	16.94 mg/L	2.03 mg/L	5.08 mg/L
Temperature	20.44 Deg C	19.99 Deg C	20.59 Deg C	20.2 Deg C
Saturation	227.54 %	186.24 %	22.55 %	56.12 %
Pressure	352.64 Torr	289.61 Torr	36.54 Torr	87.48 Torr

Gas Detectors	
LEL	-0.1 %
NH3	0.03 PPM
O2	20.92 %
Batteries	27.4 VDC

Figure 5.30. Screenshot of the System Interface Screen

Figure 5.31. Photograph of the Completed System

5.5 FIELD TESTING

The field demonstration was performed over a period of approximately 18 months, and included the following major activities/phases:

- Baseline Sampling
- Phase 1: Oxygen-Only Biosparging (9.5 weeks)
- Phase 2: System O&M (12 months)
- Phase 3: Post Treatment Monitoring (3 months after system shutdown)

Table 5.6 summarizes the pertinent events that occurred within each of these activities/phases, along with their timing and duration. Each of these activities/phases are described in detail in the following subsections.

Table 5.6. Summary of Demonstration Activities/Phases

Event Description	Day from System Start-up	Start Date	Duration	Comments
Baseline				
Baseline Sampling	-6	7/17/2019	2 Days	Baseline Groundwater Sampling (27 wells)
Phase 1: Oxygen-Only Sparging				
Begin Phase 1 System Startup	0	7/23/2019	-	Begin Phase 1
Down-Well Groundwater DO	0	7/23/2019	1 Day	Startup DO Monitoring (27 wells)
Down-Well Groundwater DO	1	7/24/2019	1 Day	Startup DO Monitoring (27 wells)
Down-Well Groundwater DO	2	7/25/2019	1 Day	Startup DO Monitoring (27 wells)
Down-Well Groundwater DO	3	7/26/2019	1 Day	Startup DO Monitoring (27 wells)
Down-Well Groundwater DO	7	7/30/2019	1 Day	Startup DO Monitoring (27 wells)
Down-Well Groundwater DO	8	7/31/2019	1 Day	Startup DO Monitoring (27 wells)
Down-Well Groundwater DO	9	8/1/2019	1 Day	Startup DO Monitoring (27 wells)
Phase 1 Oxygen Only Sparging Groundwater Sampling Event	35	8/27/2019	3 Days	Groundwater Sampling (27 wells)
Phase 1 Pre Substrate Groundwater Sampling Event	49	9/10/2019	1 Day	Groundwater Sampling (4 wells)
Phase 2: Cometabolic System Operation and Monitoring				
Begin Phase 2 Oxygen and Propane/Ammonia Sparging	68	9/29/2019	-	Begin cometabolic gas sparging
Groundwater Propane & Ammonia Monitoring Event #1	71	10/2/2019	1 Day	Groundwater Sampling (8 wells)
Groundwater Propane & Ammonia Monitoring Event #2	78	10/9/2019	1 Day	Groundwater Sampling (8 wells)
Groundwater Propane & Ammonia Monitoring Event #3	85	10/16/2019	1 Day	Groundwater Sampling (8 wells)
Performance Groundwater Sampling Event #1	91	10/22/2019	3 Days	Groundwater Sampling (27 wells)
Groundwater Propane & Ammonia Monitoring Event #4	111	11/11/2019	1 Day	Groundwater Sampling (11 wells)
Groundwater Propane & Ammonia Monitoring Event #5	120	11/20/2019	1 Day	Groundwater Sampling (9 wells)
Performance Groundwater Sampling Event #2	138	12/8/2019	3 Days	Groundwater Sampling (27 wells)
Groundwater Propane & Ammonia Monitoring Event #6	163	1/2/2020	1 Day	Groundwater Sampling (10 wells)
Groundwater Propane & Ammonia Monitoring Event #7	174	1/13/2020	1 Day	Groundwater Sampling (10 wells)
Groundwater Propane & Ammonia Monitoring Event #8	175	1/14/2020	1 Day	Groundwater Sampling (11 wells)
Groundwater Propane & Ammonia Monitoring Event #9	177	1/16/2020	1 Day	Groundwater Sampling (11 wells)
Groundwater Propane & Ammonia Monitoring Event #10	181	1/20/2020	1 Day	Groundwater Sampling (11 wells)
Groundwater Propane & Ammonia Monitoring Event #11	189	1/28/2020	1 Day	Groundwater Sampling (11 wells)
Groundwater Propane & Ammonia Monitoring Event #12	196	2/4/2020	1 Day	Groundwater Sampling (11 wells)
Groundwater Propane & Ammonia Monitoring Event #13	204	2/12/2020	1 Day	Groundwater Sampling (11 wells)
Performance Groundwater Sampling Event #3	217	2/25/2020	3 Days	Groundwater Sampling (27 wells)
Groundwater Propane & Ammonia Monitoring Event #14	240	3/19/2020	1 Day	Groundwater Sampling (11 wells)
Groundwater Propane & Ammonia Monitoring Event #15	268	4/16/2020	1 Day	Groundwater Sampling (11 wells)
Performance Groundwater Sampling Event #4	293	5/11/2020	3 Days	Groundwater Sampling (27 wells)
Performance Groundwater Sampling Event #5	356	7/13/2020	2 Days	Groundwater Sampling (27 wells)
Final Propane/Ammonia Sparge Cycle	412	9/7/2020	-	End cometabolic gas sparging
Performance Groundwater Sampling Event #6	421	9/16/2020	2 Days	Groundwater Sampling (27 wells)
Phase 3: Post Treatment Monitoring				
Post Treatment Groundwater Sampling Event	517	12/21/2020	2 Days	Groundwater Sampling (27 wells)

5.5.1 Baseline Sampling

Baseline groundwater samples were collected from all 27 monitoring wells on July 17-18, 2019, prior to system startup. Samples were analyzed for VOCs, reduced gases (methane, ethane, ethene, propane, and acetylene), total ammonia, and anions (chloride, nitrate, nitrite, phosphate, and sulfate) by APTIM's analytical laboratory in Lawrenceville, NJ, as detailed in **Section 5.6.2**. Quantification of target cometabolic organisms/genes by quantitative polymerase chain reaction (qPCR) was performed by Microbial Insights (Knoxville, TN) on samples collected from four select wells. Geochemical parameters (DO, ORP, pH, specific conductivity) were measured at each well in the field during sample collection. Additionally, baseline water level measurements were collected at all 27 monitoring wells and vapor samples were collected from four vapor probes (VP-1 through VP-4) on July 20 and July 23, 2019, respectively. The gas samples were analyzed in the field for VOCs, oxygen, hydrogen sulfide, carbon monoxide, and percent LEL using a PID and combustible gas meter. Sampling and analytical methods, sampling locations, and a list of the number and types of samples collected are provided in **Section 5.6**, and the results discussed in **Section 5.7**. The results for each well for each parameter are provided in **Appendix D** on a well-by-well basis. The data collected during this event were used as baseline measurements of site conditions prior to system operation.

5.5.2 Phase 1: Oxygen-Only Biosparging

Startup of the biosparging system with oxygen-only biosparging (Phase 1) was initiated on July 23, 2019 (day 0) and continued through September 28, 2019 (day 67). As detailed in **Section 5.4.4**, oxygen sparge cycles consisted of oxygen flowing sequentially into each of the 22 biosparging wells at a set flow rate and duration. Once all 22 wells have been sparged with oxygen, the system was flushed with nitrogen to remove the pure oxygen from the process tubing and well casing headspace. The first oxygen sparging cycle was performed at a flow rate of 10 SCFM for 10 minutes per well. DO concentrations were monitored at 23 of the 27 monitoring wells using a portable down well DO probe, and at the remaining four monitoring wells (PMW-0-3, PMW-0-4, PMW-1-3 and PMW-1-4) via the dedicated RDO probes (as detailed in **Section 5.4.4)** seven different days during the first 2 weeks of system operation to evaluate oxygen distribution and concentration changes within the biobarrier.

The oxygen sparge cycles during the first 6 weeks of operation consisted of oxygen flowing at between 10-15 SCFM sequentially into each of the 22 sparge wells for between 2 and 10 minutes. Four sparging cycles were performed over the first week of operation, and DO concentrations were regularly measured in the performance monitoring wells. Varying sparge rates and durations, and multiple shorter sparge cycles were performed over the next 5 weeks to determine the optimal approach to distribute oxygen within the treatment zone. Oxygen-only sparging was generally performed 2-3 times per week using this approach for the remaining 3 weeks of Phase 1. A total of 3,271 lbs. (39,413 cu. ft) of oxygen was sparged into the aquifer during Phase 1 operation. A table summarizing oxygen sparging data for the demonstration is provided in **Appendix E**.

A full round of groundwater sampling (27 wells) was performed on August 27-29, 2019. Groundwater samples were analyzed for VOCs, reduced gases, total ammonia, and anions by APTIM's analytical laboratory, as detailed in **Section 5.6.2**. Groundwater samples were also collected from four select wells on September 10, 2019. These groundwater samples were analyzed for VOCs, reduced gases, and anions by APTIM, and quantification of target cometabolic organisms/ genes by qPCR by Microbial Insights. Geochemical parameters were measured at each well in the field during sample collection. Additionally, one round of vapor samples was collected on August 7, 2019 from four vapor probes and analyzed in the field for VOCs, oxygen, hydrogen sulfide, carbon monoxide, and percent LEL using a PID and combustible gas meter. Sampling and analytical methods, sampling locations, and a list of the number and types of samples collected are provided in **Section 5.6**, and the results discussed in **Section 5.7**. The results for each well for each parameter are provided in **Appendix D** on a well-by-well basis.

System operations data (gas flows, pressures, cycle frequencies, and downtime) and DO data collected from the four dedicated RDO probes were recorded and stored in data files by the SCADA system on the system laptop.

5.5.3 Phase 2: System Operation and Monitoring

After the oxygen-only biosparging phase was completed, the biosparging system started operating in cometabolic sparging mode (Phase 2) on September 29, 2019 (day 68). A total of 24 cometabolic sparging cycles were performed over 12 months during Phase 2 operation. The cometabolic biosparging cycles consisting of a mix of propane, ammonia, and nitrogen gases, as described in **Section 5.4.4**. The cometabolic sparge cycles typically consisted of the combined mixed gases flowing at between 7.5-12 SCFM sequentially into each of the 22 sparge wells for 5 minutes per well. The frequency of the sparging events slowly increased over the first 15 weeks of Phase 2 (as increased propane degradation was observed), at which time sparging cycles were generally performed every 7-14 days for the remainder of the demonstration. The last cometabolic sparge cycle was performed on September 7, 2020 (day 412). A total of 349.4 lbs. (3,065 cu. ft) of propane, 67.6 lbs. (1,536 cu. ft) of ammonia, and 1,140.4 lbs. (15,752 cu. ft) of nitrogen were sparged into the aquifer during Phase 2 operation. A table summarizing cometabolic sparging data for the demonstration is provided in **Appendix E**.

Performance monitoring events that included collecting groundwater samples from all 27 monitoring wells were conducted 6 times during Phase 2. Additionally, 15 smaller monitoring events that included collecting groundwater samples from between 8 and 11 select monitoring wells were conducted to evaluate the distribution and degradation of gaseous amendments (e.g., propane and ammonia). Samples collected during the 6 performance monitoring events were analyzed for VOCs, reduced gases, total ammonia, and anions by APTIM's analytical laboratory. Quantification of target cometabolic organisms/genes by qPCR was performed by Microbial Insights on samples collected from four select wells during two of the sampling events. Samples collected during the 15 gas distribution sampling events were analyzed by APTIM's analytical laboratory for reduced gases and ammonia, with select samples being analyzed for VOCs and/or anions. Geochemical parameters were measured at each well in the field during sample collection. Additionally, vapor samples were collected twice from four vapor probes during Phase 2. The gas samples were analyzed in the field for VOCs, oxygen, hydrogen sulfide, carbon monoxide, and percent LEL using a PID and combustible gas meter. Sampling and analytical methods, sampling locations, and a list of the number and types of samples collected are provided in **Section 5.6**, and the results discussed in **Section 5.7**. The results for each well for each parameter are provided in **Appendix D** on a well-by-well basis.

System O&M consisted of regular (every 2-4 weeks) system checks (to collect manual system pressure and flow data, perform regular system maintenance, and perform leak checks) and changeout of the oxygen 16-packs approximately every 2-3 months. The nitrogen 16-pack required less frequent changeouts. Changeout of the oxygen and nitrogen 16-packs required the use of an off-road forklift. The 6 tanks of liquified propane and 4 tanks of liquified ammonia did not require replacement during the demonstration. System operations data (gas flows, pressures, cycle frequencies, and downtime) and DO data collected from the four dedicated RDO probes were recorded and stored in data files by the SCADA system on the system laptop.

5.5.4 Post Treatment Monitoring

Post treatment groundwater samples were collected from all 27 monitoring wells on December 21-22, 2020, approximately three months after the biosparging system had been shut down. Samples were analyzed for VOCs, reduced gases, total ammonia, and anions by APTIM's analytical laboratory. Quantification of target cometabolic organisms/genes by qPCR was performed by Microbial Insights on one select sample collected during the event. Geochemical parameters were measured at each well in the field during sample collection. Sampling and analytical methods, sampling locations, and a list of the number and types of samples collected are provided in **Section 5.6**, and the results discussed in **Section 5.7**. The results for each well for each parameter are provided in **Appendix D** on a well-by-well basis. The data collected during this event were used to evaluate potential continued cVOC degradation or contaminant rebound, and geochemical changes both within and downgradient of the treatment zone after biosparging had stopped.

5.5.5 Decommissioning

All tubing and wiring connections to the biosparging system were disconnected, and the system secured for shipping on December 2-3, 2020. The system was shipped to Naval Air Station (NAS) North Island on December 4, 2020 to be utilized for ESTCP project ER-201733. The solar panels, mounting racks, and support poles were removed on December 29, 2020. All biosparging wells, monitoring wells, and vapor probes were abandoned in accordance with relevant state regulations, all underground tubing was removed, and the site was restored between June 22-24, 2021. Four drums containing groundwater sampling purge water were transported off-site for disposal on October 2, 2021.

5.6 SAMPLING METHODS

Groundwater sampling within and surrounding the treatment zone were conducted to measure contaminant concentrations and distribution, measure gas amendment concentrations and distribution, quantify target cometabolic organisms/genes, and assess subsurface geochemical conditions. All activities were conducted in accordance with the site-specific health and safety documents contained in the Site-Specific Safety and Health Plan (SSHP), presented in the ESTCP-approved Demonstration Plan for the project.

5.6.1 Groundwater Sampling

Groundwater samples were collected utilizing a peristatic pump and low-flow techniques. Prior to each sampling event, the well ID and sample interval were confirmed and recorded on a field data collection form. Groundwater depth measurements were then collected using an electronic water level probe (Solinst 101 water level meter, or equivalent) prior to purging and collecting groundwater samples. Water depth measurements were obtained from the surveyed mark on the top of the well casing and recorded to the nearest 0.01-ft on the field forms. Depth to water measurements were used to determine water table elevations and hydraulic gradient within the demonstration area, including the potential for water table mounding during gas injection cycles.

Dedicated Teflon tubing was used to sample each of the wells, which did not require decontamination between sampling events. A peristaltic pump with dedicated tubing was used to withdraw water from the wells at a typical flow rate between 0.1 to 0.25 L/min. The water level in the well was monitored and recorded during purging. Drawdown during purging was limited to <0.3 ft.

Purged water was pumped through a flow cell connected to an in-line multi-parameter groundwater meter (YSI 6920 or equivalent). Parameters, including temperature, conductivity, DO, ORP, turbidity, and pH were measured as a function of pumping time, and the values recorded on a field sheet approximately every 5 minutes. Water was purged from the well until all parameters were stable for three consecutive readings, or for a maximum of 30 minutes (to minimize the volume of groundwater removed from the formation in the closely-spaced well intervals). Stability was defined as variation of <1% for pH, <3% for temperature and specific conductivity, and <10% for DO, ORP, and turbidity. When parameters were stable according to the above guidelines, the sampling time was recorded, and all samples were collected.

The procedures used in collecting groundwater samples during the demonstration are described below. After the well parameters stabilized during low flow purging, or the well was purged for 30 minutes (whichever came first), samples were collected from the tubing prior to the flow cell, in the following order (as applicable), using the following procedures:

- <u>VOCs</u>: Three (3) 40 milliliter (mL) glass volatile organic analysis (VOA) vials with hydrochloric acid (HCl) (pH <2) preservative and with Teflon-lined caps were filled directly from the groundwater purge stream. The bottles were filled leaving zero head-space (the bottles were filled to the top resulting in a convex meniscus). The vials were then be capped and placed on adequate ice for shipment.
- <u>Reduced gases (methane, ethane, ethene, propane, acetylene)</u>: Two (2) 40 mL glass VOA vials with HCl (pH <2) preservative and with Teflon-lined caps were filled directly from the groundwater purge stream. The bottles were filled leaving zero head-space (the bottles were filled to the top resulting in a convex meniscus). The vials were then be capped and placed on adequate ice for shipment.
- <u>Anions</u>: One (1) 100 mL sample jar (plastic, no chemical preservatives) was filled to the top with water. The jar was then capped and placed on adequate ice for shipment. This sample was used for analysis of nitrate, nitrite, sulfate, phosphate, chloride, and bromide.

- Cometabolic Organisms / Genes: One (1) 1 L sample jar (plastic, no chemical preservatives) was filled to the top with water. The jar was then capped and placed on adequate ice for shipment. This sample was used for analysis of the following:
    - Propane monooxygenase (PPO)
    - Soluble methane monooxygenase (SMMO)
    - Particulate methane monooxygenase (PMMO)
    - Ethene monooxygenase (EtnC)
    - Epoxyalkane transferase (EtnE)
    - Short chain alkane monooxygenase (SCAM)
    - Ammonia monooxygenase (AMO)
- Total Ammonia: Two (2) 40 mL glass VOA vials with sulfuric acid (H_2SO_4) (pH <2) preservative and with Teflon-lined caps were filled directly from the groundwater purge stream. The bottles were filled leaving zero head-space (the bottles were filled to the top resulting in a convex meniscus). The vials were then be capped and placed on adequate ice for shipment.
- 1,4-D: Three (3) 40 mL glass VOA vials with HCl (pH <2) preservative and with Teflon-lined caps were filled directly from the groundwater purge stream. The bottles were filled leaving zero head-space (the bottles were filled to the top resulting in a convex meniscus). The vials were then be capped and placed on adequate ice for shipment.

5.6.2 Groundwater Analysis

Groundwater samples were submitted to APTIM's Analytical and Testing Laboratory in Lawrenceville, NJ for analysis of VOCs, reduced gases, anions, total ammonia and 1,4-D. The samples for quantification of target cometabolic organisms/genes were submitted to Microbial Insights, located in Knoxville, TN. The analytical methods for groundwater samples collected during the field demonstration are summarized in **Table 5.7**. Field geochemical parameters, including pH, DO, specific conductivity, ORP, temperature, and turbidity were measured at the site during well purging using a field meter, as described in **Section 5.5.1.**

5.6.3 Vapor Sampling and Analysis

Vadose zone vapor samples were collected in dedicated Tedlar bags from vapor probes using a vacuum pump. Dedicated Teflon tubing was used to sample each of the vapor probes, and therefore did not require decontamination or replacement between sampling events. Prior to each sampling event, the vapor probe ID was confirmed and recorded. The vacuum pump was connected to the vapor probe using the dedicated tubing, and vapor from the vapor probe was withdrawn at a typical flow rate between 0.25 to 1.0 L/min. A minimum of one L of vapor was purged from the probe prior to connecting the dedicated Tedlar bag. The Tedlar bag was then connected and filled. The contents of the bag were then evacuated by placing pressure on the bag. This process was performed two more times to fully purge the Tedlar bag of any potential residual vapor from the previous sample. The Tedlar bag was then filled a fourth time. The vapor sample in the Tedlar bag was then analyzed and recorded in the field for VOCs, oxygen, hydrogen sulfide, carbon monoxide, and percent LEL using a PID and combustible gas meter.

Table 5.7. Analytical Methods for Groundwater Samples Collected during the Demonstration

Analyte[1]	Method/ Laboratory	Preservative	Bottle	Hold time
VOCs	EPA 8260 APTIM	4°C with HCl	40 mL VOA vial (x3), no headspace	14 days
Reduced Gases	EPA 3810, RSK175 APTIM[2]	4°C with HCl	40 mL VOA vial (x2) no headspace	14 days
Anions	EPA 300.0 APTIM	4°C	100 mL (x1) polyethylene screw-cap	2 days (NO_3, PO_4); 28 days all others
Cometabolic Organisms / Genes	Census DNA (qPCR) Microbial Insights	4°C	1 L (x1) polyethylene screw-cap	NA[3]
Total Ammonia	Hach Method 8155 APTIM	4°C with H_2SO_4	40 mL VOA vial (x2) no headspace	28 days
1,4-Dioxane	EPA 8260/SIM APTIM	4°C with HCl	40 mL VOA vial (x3), no headspace	14 days
Redox Potential	Field Meter	--	--	NA
Dissolved Oxygen	Field Meter	--	--	NA
pH	Field Meter	--	--	NA
Specific Conductivity	Field Meter	--	--	NA
Temperature	Field Meter	--	--	NA
Turbidity	Field Meter	--	--	NA

[1] All analyses are in groundwater

[2] Not a standard EPA Method.

[3] NA, Not applicable

5.6.4 Numbers and Types of Samples

The numbers and types of groundwater samples collected during the demonstration are summarized in **Table 5.8**. The table also provides the number of sampling events during each of the demonstration phases, including baseline sampling, system startup, and the three operational phases.

5.6.5 Decontamination and Purge Water Waste Handling and Disposal

Sampling and measuring equipment that were reused in multiple wells were decontaminated prior to use. This includes water level indicators, multi-parameter water quality meters and flow cells, DO probes, water level transducers, and any other instrumentation or material potentially exposed to contaminants. Decontamination of sampling and measurement equipment included the following:

- Initial wash using Alconox or other approved detergent;
- Rinse with potable water; and
- Air dry or drying using clean towel.

Table 5.8. Total Number and Types of Samples Collected During the Demonstration

Phase	Duration	Matrix	Number of Events	Number of Samples Per Event	Analyte	Location
Baseline Sampling	2 Days	Groundwater	1	27	VOCs	All Monitoring Wells: 24 PMW wells, 2 BMW wells and MB-30
				27	Reduced Gases	
				27	Anions	
				27	Total Ammonia	
				27	Field Parameters[1]	
				4	Cometabolic organisms/genes[2]	BMW-1D, PMW-0-3, PMW-0-4 and PMW-1-3
Phase 1: Oxygen-Only Sparging	2 Weeks (System Startup)	Groundwater	7	27	Dissolved Oxygen	All Monitoring Wells: 24 PMW wells, 2 BMW wells and MB-30
	7.5 Weeks	Groundwater	1	27	VOCs	All Monitoring Wells: 24 PMW wells, 2 BMW wells and MB-30
				27	Reduced Gases	
				27	Anions	
				27	Total Ammonia	
				27	Field Parameters[1]	
		Groundwater (Pre-Substrate Event)	1	4	VOCs	BMW-1D, PMW-0-3, PMW-0-4, and PMW-1-3
				4	Reduced Gases	
				4	Anions	
				4	Field Parameters[1]	
				4	Cometabolic organisms/genes2	
Phase 2: System Operation and Monitoring	12 months	Groundwater (Performance Monitoring)	6	27	VOCs	All Monitoring Wells: 24 PMW wells, 2 BMW wells and MB-30
				27	Reduced Gases	
				27	Anions	
				27	Total Ammonia	
				27	Field Parameters[1]	
			2	4	Cometabolic organisms/genes[2]	BMW-1D, PMW-0-3, PMW-0-4 and PMW-1-3
		Groundwater (Propane and Ammonia Monitoring)	2	11	VOCs	Select PMW and BMW wells each event[4]
			15	8 to 11	Reduced Gases	
			3	6 to 11	Anions	
			15	8 to 11	Total Ammonia	
			15	8 to 11	Field Parameters[1]	
Post Treatment Monitoring	One-time event: 3 months after system shutdown	Groundwater	1	27	VOCs	All Monitoring Wells: 24 PMW wells, 2 BMW wells and MB-30
				27	Reduced Gases	
				27	Anions	
				27	Total Ammonia	
				27	Field Parameters[1]	
				1	Cometabolic organisms/genes[2]	PMW-0-3

Notes:

[1] Field parameters include pH, temperature, dissolved oxygen, oxidation/reduction potential, and specific conductivity.

[2] Census DNA (qPCR) analysis was performed by Microbial Insights and includes quantification of several target cometabolic organisms/genes.

[3] Vapor probe samples were analyzed in the field using a photoionization detector and combustible gas meter.

[4] See groundwater monitoring event summary tables in Appendix F for specific wells and analytes sampled for each monitoring event.

Decontamination fluids were pumped to 55-gallon drums, to await proper disposal (as discussed below). The use of peristaltic pumps with dedicated down-hole tubing precluded the need for decontamination of these components.

Purged groundwater during sampling, groundwater extracted during well development, and decontamination of equipment generated liquid investigation derived waste (IDW). These fluids were containerized in 55-gallon drums and temporarily staged within the demonstration area. The contents of the drums were sampled for waste characterization and subsequent off-site disposal.

5.6.6 Quality Assurance for Groundwater Sampling and Analysis

5.6.6.1 Calibration Procedures and Frequency

Calibration refers to the checking of physical measurements of both field and laboratory instruments against accepted standards. It also refers to determining the response function for an analytical instrument, which is the measured net signal as a function of the given analyte concentration. These determinations have a significant impact on data quality and are performed regularly. In addition, preventative maintenance is important to the efficient collection of data. For preventative maintenance purposes, critical spare parts were obtained from the instrument manufacturer.

All field and laboratory instruments were calibrated according to manufacturers' specifications. All APTIM laboratory instruments were calibrated in accordance with established Standard Operating Procedures. Calibration was performed prior to initial use, during periods of extended use, and after periods of non-use. Certified standards were used for all calibrations and calibration check measurements. A calibration logbook was maintained by APTIM field and laboratory quality assurance personnel.

5.6.6.2 Quality Control Samples

Internal quality control (QC) data provides information for identifying and defining qualitative and quantitative limitations associated with measurement data. Analysis of the following types of QC samples provided the primary basis for quantitative evaluation of field data quality:

Field QC Samples:

- Trip blanks to evaluate the presence of contamination from handling errors or cross-contamination during transport; and
- Field duplicates to assess the homogeneity of samples received by the laboratory as well as the homogeneity of contaminants in the matrix.

5.6.6.3 Trip Blanks

Trip blanks were prepared by the analytical laboratory with purified water for groundwater samples. The water was sent to the site in the same containers to be used for collection of the samples. Trip blanks were submitted at a frequency of one trip blank per shipment of samples for VOC analysis. For non-VOC analyses, no trip blanks were deemed necessary, and none were submitted.

5.6.6.4 Field Duplicate Samples

Field duplicate samples were analyzed for all parameters, except quantification of target cometabolic organisms/genes, to evaluate the accuracy of the analytical process. Each duplicate was run at a frequency of at least 5 percent of the total number of environmental samples. A comparison of the detected concentrations in the duplicate samples was performed to evaluate precision.

5.6.6.5 Sample Documentation

APTIM Lawrenceville, NJ project staff coordinated shipment and receipt of sample bottles, coolers, ice packs, chain of custody (COC) forms, and custody seals. Upon completion of sampling, the COC was filled out and returned with the samples to the APTIM and Microbial Insights laboratories. An electronic copy of each COC form was placed in the project database. An important consideration for the collection of environmental data is the ability to demonstrate that the analytical samples have been obtained from predetermined locations and that they have reached the laboratory without alteration. Evidence of collection, shipment, laboratory receipt, and laboratory custody until disposal was documented to accomplish this. Documentation was accomplished through a COC Record that recorded each sample and the names of the individuals responsible for sample collection, transport, and receipt. A sample was considered in custody if it was:

- in a person's actual possession;
- in view after being in physical possession;
- sealed so that no one can tamper with it after having been in physical custody; or
- in a secured area, restricted to authorized personnel.

Sample custody was initiated by field personnel upon collection of samples. Samples were packaged appropriately to prevent breakage or leakage during transport, and shipped to the laboratory via commercial carrier.

5.6.6.6 Sample Identification

A discrete well number was assigned to each sample. This discrete identifier was placed on each bottle and recorded, along with other pertinent data, in a field notebook and/or field forms dedicated to the project. The sample identification number designated the sample location (e.g., "PMW-1S"). The bottle label also contained the site name, the sampling date and time, any preservatives added to the bottle, and the initials of the sampler.

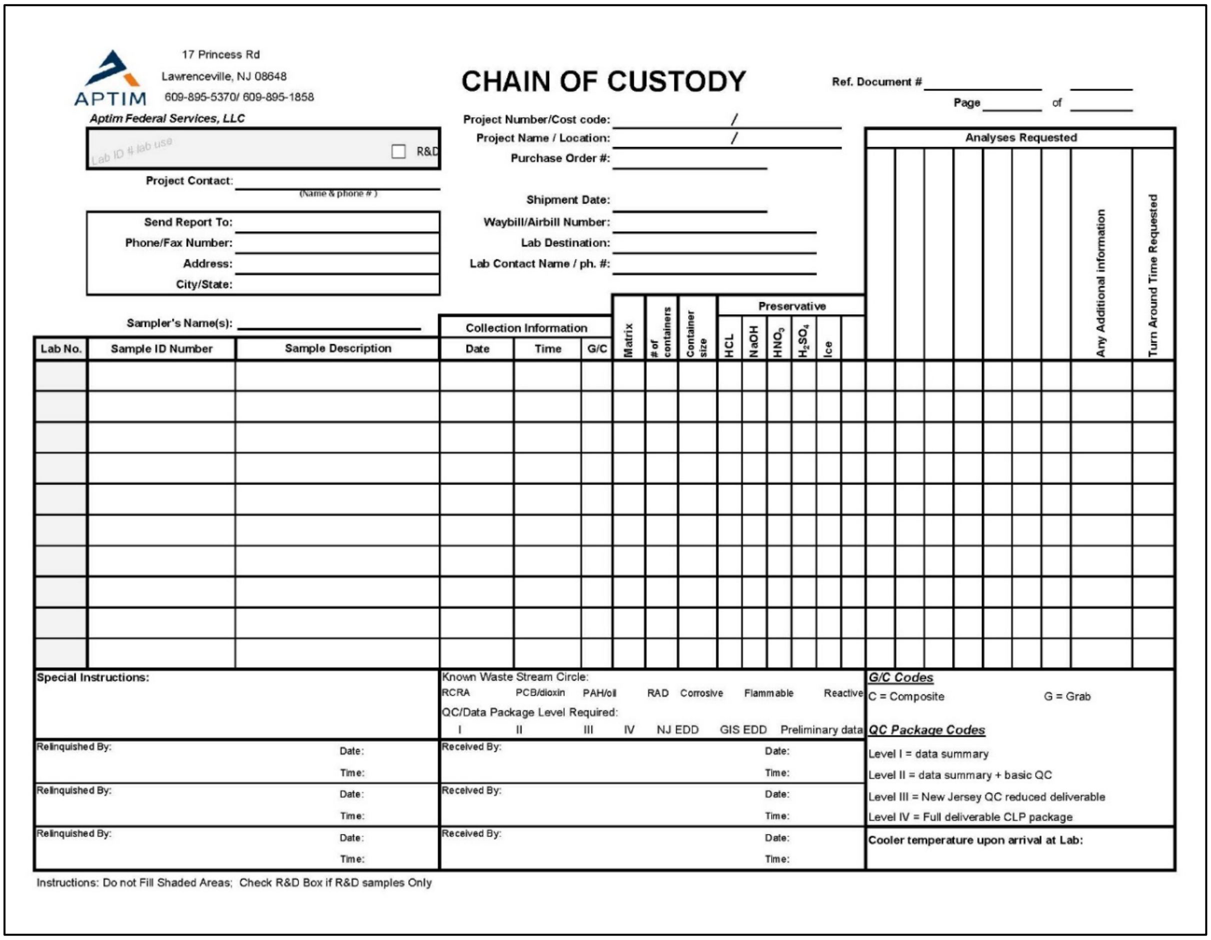
5.6.6.7 Chain-of Custody Forms

The COC Record that was used by APTIM's laboratory is shown in **Figure 5.32**. All samples collected for off-site analysis were physically inspected by the field sampler prior to shipment.

Each individual who had samples in their possession were required to sign the COC Record. Preparation of the COC Record will be as follows:

- The COC Record was initiated in the field by the person collecting the sample, for every sample. Every sample was assigned a unique identification number entered on the COC Record.

- The record was completed in the field to indicate project, sampling person, etc.
- The person delivering the samples for shipment signed the COC record as "Relinquished By ________".
- The original COC Record was sealed in a watertight bag, taped to the top (inside) of the shipping container, and the shipping container was sealed prior to being given to the commercial carrier.



APTIM
17 Princess Rd
Lawrenceville, NJ 08648
609-895-5370/ 609-895-1858
Aptim Federal Services, LLC

CHAIN OF CUSTODY

Ref. Document # ____________ ________
Page ______ of ______

Lab ID # lab use ☐ R&D

Project Contact: ____________
(Name & phone #)

Send Report To: ____________
Phone/Fax Number: ____________
Address: ____________
City/State: ____________

Project Number/Cost code: ______ / ______
Project Name / Location: ______ / ______
Purchase Order #: ____________

Shipment Date: ____________
Waybill/Airbill Number: ____________
Lab Destination: ____________
Lab Contact Name / ph. #: ____________

Sampler's Name(s): ____________

			Collection Information						Preservative						Analyses Requested								
Lab No.	Sample ID Number	Sample Description	Date	Time	G/C	Matrix	# of containers	Container size	HCL	NaOH	HNO_3	H_2SO_4	Ice									Any Additional information	Turn Around Time Requested

Special Instructions:

Known Waste Stream Circle:
RCRA PCB/dioxin PAH/oil RAD Corrosive Flammable Reactive
QC/Data Package Level Required:
I II III IV NJ EDD GIS EDD Preliminary data

G/C Codes
C = Composite G = Grab

QC Package Codes
Level I = data summary
Level II = data summary + basic QC
Level III = New Jersey QC reduced deliverable
Level IV = Full deliverable CLP package

Relinquished By:	Date: Time:	Received By:	Date: Time:	
Relinquished By:	Date: Time:	Received By:	Date: Time:	
Relinquished By:	Date: Time:	Received By:	Date: Time:	**Cooler temperature upon arrival at Lab:**

Instructions: Do not Fill Shaded Areas; Check R&D Box if R&D samples Only

Figure 5.32 Chain of Custody (COC) Form Used by APTIM's Laboratory.

The commercial waybill served as an extension of the COC Record between the final field custodian and receipt by the off-site laboratory.

- Upon receipt by the off-site laboratory, the laboratory QC Coordinator, or designated representative, opened the shipping container(s), compared the contents with the COC Record, and signed and dated the record. Any discrepancies were noted on the COC Record.
- COC Records were maintained with the records for the project and became part of the data package.

5.6.6.8 Laboratory Sample Receipt

Following sample receipt, the Laboratory Manager or qualified personnel:

- Examined all samples and determined if proper temperature had been maintained during transport. If samples had been damaged during transport, the remaining samples were carefully examined to determine whether they were affected;
- Compared samples received against those listed on the COC record;
- Verified that sample holding times were not exceeded;
- Signed and dated the COC record;
- Recorded samples in the laboratory sample log-in book containing, at a minimum, the following information:
  - Project identification number
  - Sample numbers
  - Type of samples
  - Date and time received
- Placed the COC Record in the project file.

5.6.6.9 Other Documentation

Following sample receipt at the laboratory, the Laboratory Manager or sample custodian clearly documented the processing steps applied to the sample. The analytical data from laboratory QC samples were identified with each batch of related samples. The laboratory logbook included the time, date, and name of the person who logged each sample into the laboratory system. This documentation was thorough enough to allow tracking of the sample analytical history without aid from the analyst, if needed. At a minimum, laboratory documentation procedures provided the following:

- Recording in a clear, comprehensive manner using indelible ink.
- Corrections to data and logbooks made by drawing a single line through the error and initialing and dating the correction.
- Consistency before release of analytical results by assembling and cross-checking the information on the sample tags, custody records, bench sheets, personal and instrument logs, and other relevant data to verify that data pertaining to each sample are consistent throughout the record.
- Observations and results identified with the project number, date, and analyst and reviewer signatures on each line, page, or book as appropriate.
- Data recorded in bound books or sheaf of numbered pages, instrument tracings or hard copy, or computer hard copy.
- Data tracking through document consolidation and project inventory of accountable documents: sample logbook, analysis data book, daily journal, instrument logbook, narrative and numerical final reports, etc.

5.7 SAMPLING RESULTS

The results from the performance monitoring conducted during baseline sampling, the two operations phases, and post treatment sampling are summarized in the following subsections. As discussed in **Section 5.5.3**, and as summarized in **Table 5.8**, the majority of the performance sampling was performed during Phase 2 of the demonstration. The results for each well for each parameter are provided in **Appendix D** on a well-by-well basis.

5.7.1 Chlorinated VOCs

The overall objective of this work was to treat *cis*-DCE and VC to below MCLs, showing that cometabolism can be utilized to meet these stringent objectives. To evaluate effectiveness, cVOC concentrations in groundwater were monitored. The performance monitoring well network (**Figure 5.10**) consisted of a total of 27 monitoring wells located within, upgradient and downgradient of the biobarrier and within and above the defined plume, as described in **Section 5.4.1**. Most of the monitoring wells were grouped in clusters containing between 2 and 4 wells screened across discrete intervals of the aquifer (except well MB-30, which is more broadly screened), at varying distances from the line of biosparging wells (**Figures 5.10** and **5.12**).

To evaluate treatment performance within and downgradient of the biobarrier, the wells were grouped into two primary categories:

- 5-10’ Wells: Ten performance monitoring wells were located within the targeted 20’ wide biobarrier, between 5 and 10 ft downgradient of the line of biosparging wells. These wells were designated PMW-0-2, PMW-0-3, PMW-0-4, PMW-1-2, PMW-1-3, PMW-1-4, PMW-2I, PMW-2D, PMW-3I and PMW-3D. The evaluation of *cis*-DCE treatment performance also included the shallowest wells in the two 5-10’ downgradient well clusters (PMW-0-1 and PMW-1-1), as these wells exhibited elevated *cis*-DCE concentrations (although, below the MCL) during baseline sampling. These 2 wells were not included in the evaluation of VC treatment performance, as concentrations were typically below the reporting limit of 1 μg/L during the demonstration.
- 15-25’ Wells: Eight performance monitoring wells were located immediately downgradient of the designed biobarrier, between 15 and 25 ft downgradient of the line of biosparging wells. These wells were designated PMW-2-2, PMW-2-3, PMW-2-4, PMW-3-2, PMW-3-3, PMW-3-4, PMW-4D and MB-30. The evaluation of *cis*-DCE treatment performance also included the shallowest wells in the two 15-25’ downgradient well clusters (PMW-2-1 and PMW-3-1), as these wells exhibited elevated *cis*-DCE concentrations (although, below the MCL) during baseline sampling. These 2 wells were not included in the evaluation of VC treatment performance, as concentrations were typically below the reporting limit of 1 μg/L during the demonstration.

The *cis*-DCE and VC concentration data collected from these two groups of wells during the field demonstration are graphed, along with data from background monitoring well BMW-1I, on **Figures 5.33** through **5.36**. These graphs also indicate the start of oxygen sparging (Day 0) and the timing of each of the 25 propane/ammonia sparging events (starting on day 68).

cis-DCE

As shown on **Figures 5.33** and **5.34**, baseline *cis*-DCE concentrations at the 22 performance monitoring wells located between 5 and 25 ft downgradient of the sparge wells ranged between 10.6 µg/L and 92.6 µg/L, and generally remained relatively stable from the beginning of the demonstration through sampling events performed on days 139 to 163. There were no significant changes in *cis*-DCE concentrations observed during the 67 days of Phase 1 oxygen-only sparging, indicating that stripping of this compound was not occurring due to oxygen sparging. Additionally, as anticipated, there were no reductions in *cis*-DCE concentrations for an approximate 2.5 to 3-month period after the initiation of propane and ammonia biosparging on day 68, as biomass density in the aquifer was likely not yet sufficient to rapidly consume the added propane and subsequently degrade the target contaminants (i.e., cell growth phase). It was shortly after this time interval that significant decreases in *cis*-DCE concentrations were observed in 20 of the 22 wells, with concentrations continuing to decline until approximately day 294. Concentrations remained low throughout the remainder of the field demonstration, which ended on day 422, when the final performance sampling round occurred. There were no significant decreases in *cis*-DCE concentrations observed at wells PMW-3D and PMW-4D during Phase 2 of the demonstration. However, target dissolved propane and DO concentrations were not achieved at these locations (as discussed in **Sections 5.7.3** and **5.7.4**), which presumably limited growth of the propanotrophs responsible for *cis*-DCE biodegradation in the aquifer.

The average *cis*-DCE concentrations measured at the cluster of 4 wells (PMW-3-1, PMW-3-2, PMW-3-3, and PMW-3-4) located 25 ft downgradient of the sparge wells during baseline sampling (day -5) and the final performance monitoring event (day 422) are presented in **Figure 5.35**. The data show a 98% decrease in average *cis*-DCE concentrations between these two time points, with averaged concentrations decreasing from 57.7 µg/L to 1.1 µg/L. While *cis*-DCE concentrations at all 22 wells were consistently below the MCL of 70 µg/L between days 181 and 422 of the demonstration, the data show that degradation continued further downgradient of the designed 20 ft wide biobarrier (beyond the 5-10' wells). The change in representative mass flux of *cis*-DCE through and downgradient of the barrier is discussed further in **Section 5.7.2**.

Although not presented in the graphs, the data from wells PMW-1S, PMW-1I, and PMW-1D (**Appendix D**), located 8 ft upgradient of the sparge wells (near the upgradient edge of the designed 20 ft wide biobarrier), showed little biodegradation of *cis*-DCE. We expected the injected gases to reach ~ 10 ft upgradient of the sparge wells, and thus impact these wells. However, propane was detected above detection at only one of these three wells (see **Section 5.7.3**). That being said, a review of all cVOC data collected from upgradient and downgradient of the sparge wells as well as dissolved propane and DO data (as discussed in **Sections 5.7.3** and **5.7.4, respectively)**, indicate that the biobarrier was wider than designed (~30 ft compared to 20 ft), but that it started further downgradient than expected. This field observation likely results from the relatively high groundwater velocity (~0.5 ft/day) transporting amendments further downgradient than anticipated, and the strongly anaerobic groundwater flowing into the biobarrier continuously consuming oxygen and preventing propanotroph growth in the gas-impacted zone most upgradient of the sparge wells.

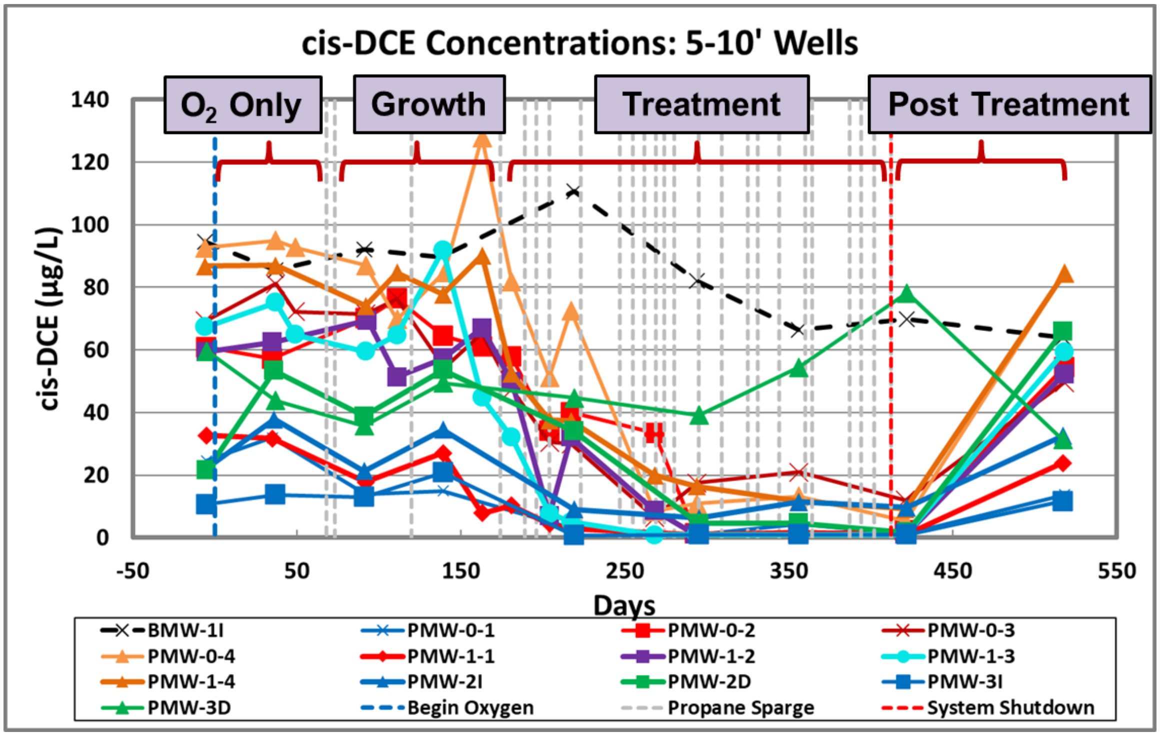


Figure 5.33 *cis*-DCE Concentrations at Wells Located 5-10' Downgradient of the Sparge Wells

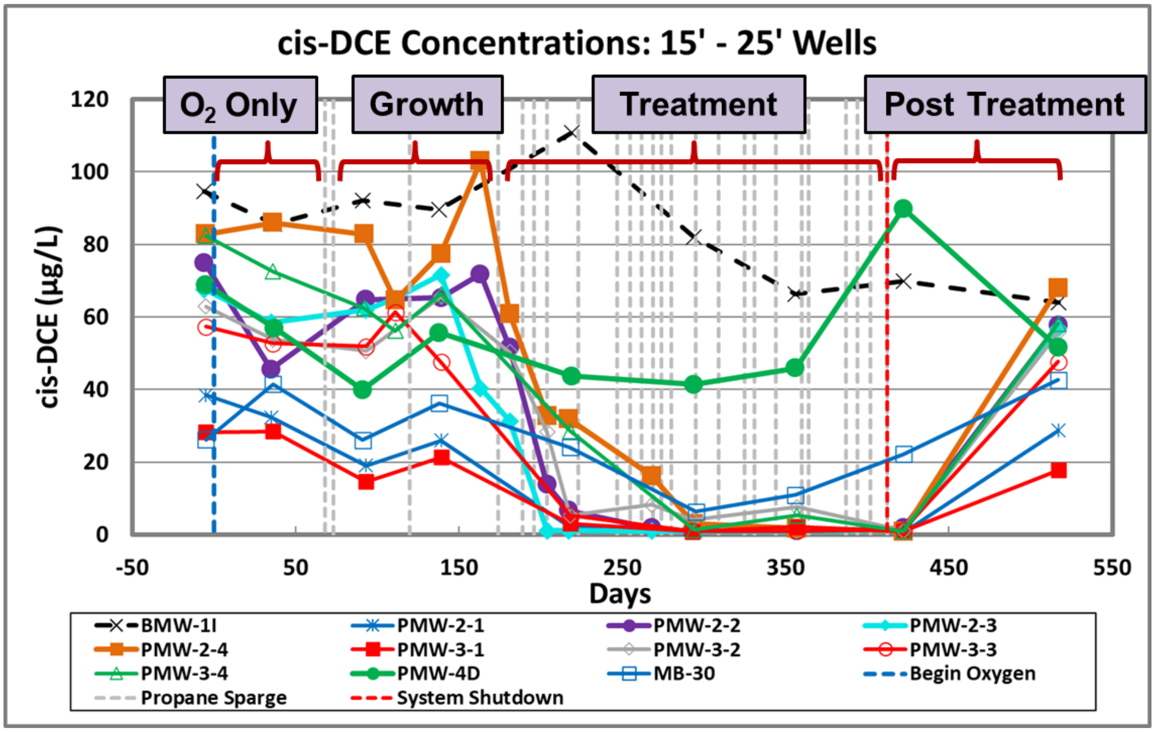


Figure 5.34 *cis*-DCE Concentrations at Wells Located 15-25' Downgradient of the Sparge Wells

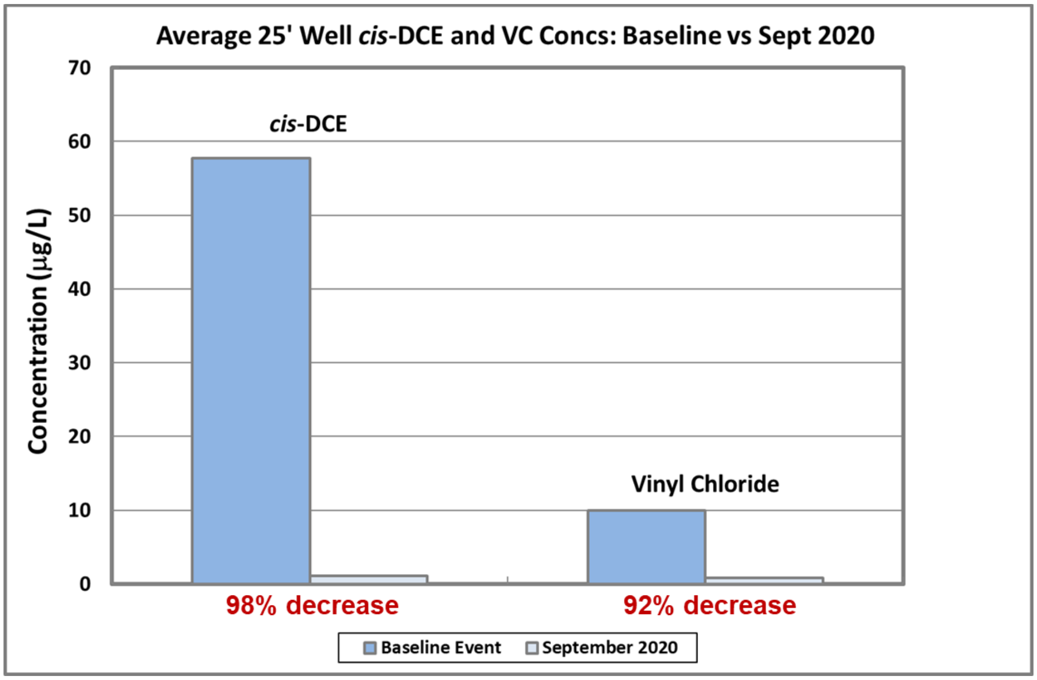


Figure 5.35 Averaged 25' Well *cis*-DCE and Vinyl Chloride Concentration.

cis-DCE concentration average includes wells PMW-3-1, PMW-3-2, PMW-3-3 and PMW-3-4. VC concentration average includes wells PMW-3-2, PMW-3-3 and PMW-3-4 (VC concentrations at PMW-1-1 were not included in the average, as they were below 1 µg/L throughout the demonstration).

As shown on **Figures 5.33** and **5.34**, *cis*-DCE generally returned to near baseline concentrations at most of the wells during the post treatment sampling event performed on day 517 (105 days after the final propane/ammonia biosparging cycle). As anticipated, in the absence of oxygen and cometabolic substrate addition (and possibly nutrient addition), the degradative activity of the propane oxidizing bacteria that were grown within the treatment zone ceased, and contaminated groundwater flowing through this area was no longer being treated.

Vinyl Chloride

As shown on **Figures 5.36** and **5.37**, baseline VC concentrations at the 18 performance monitoring wells located between 5 and 25 ft downgradient of the sparge wells ranged between non-detect (<1.0 µg/L) and 24.7 µg/L. Unlike *cis*-DCE, VC concentrations decreased at several of the downgradient monitoring wells during the Phase 1 oxygen-only sparging period. This was expected, as results from the microcosm studies (**Section 5.3.1**) clearly showed that the addition of oxygen (without a cometabolic substrate or nutrients) led to significant decreases in VC concentrations relative to the killed controls. This suggests that there are indigenous bacteria capable of either metabolizing VC directly, or utilizing another co-substrate (such as methane, which was present in the aquifer) for cometabolism of the VC (e.g., Verce et al., 2000; 2001). Concentrations of VC generally decreased more rapidly in the wells between sampling events performed on days 139 and 163 (~2.5 to 3 months after initiation of propane and ammonia biosparging). VC concentrations were below the MCL of 2 µg/L at 15 of the 18 wells by day 294 and remained low for the remainder of the field demonstration. VC concentrations were below the MCL at 16 of the 18 wells during the final performance sampling event conducted on day 422.

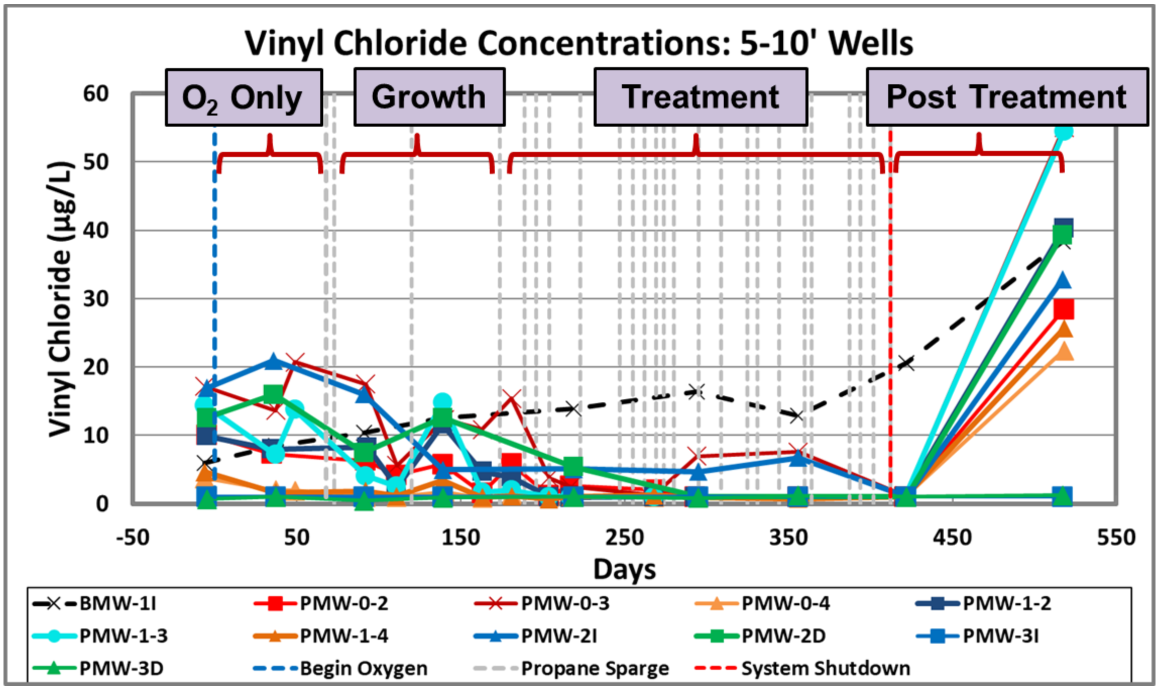


Figure 5.36 Vinyl Chloride Concentrations at Wells Located 5-10’ Downgradient of the Sparge Wells

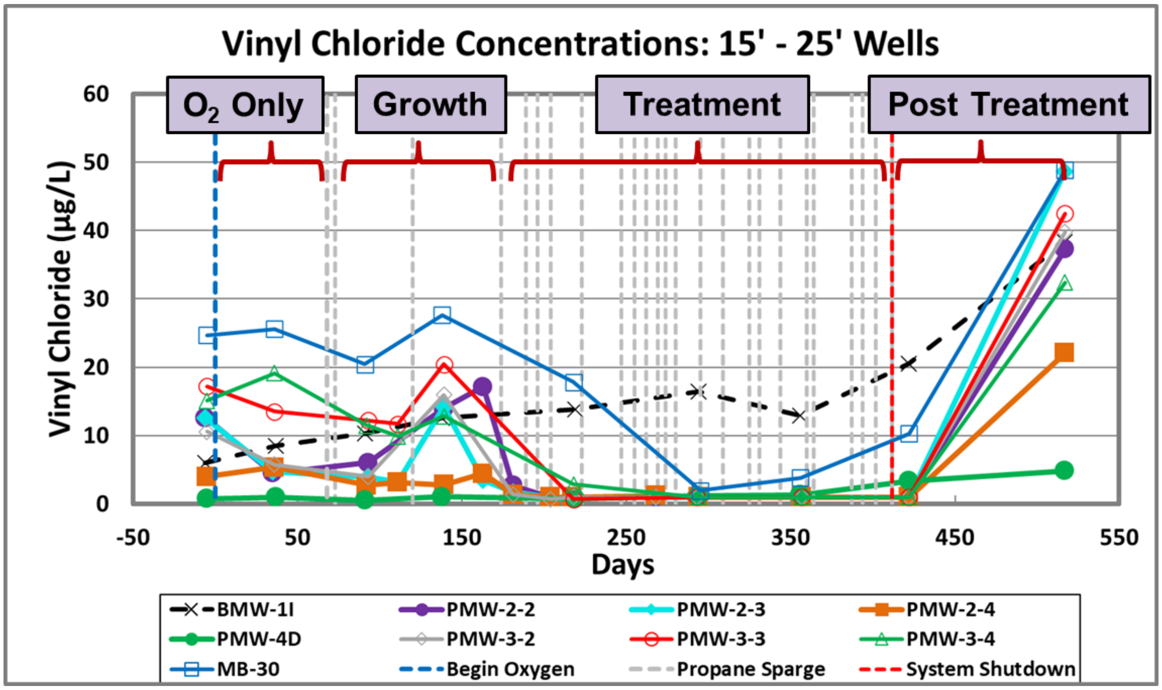


Figure 5.37 Vinyl Chloride Concentrations at Wells Located 15-25’ Downgradient of the Sparge Wells

The averaged VC concentrations measured at three of the well wells (PMW-3-2, PMW-3-3, and PMW-3-4) located 25 ft downgradient of the sparge wells during baseline sampling (day -5) and the final performance monitoring event (day 422) are presented in **Figure 5.35**. The data show a 92% decrease in averaged VC concentrations between these two time points, with averaged concentrations decreasing from 10.0 µg/L to 0.8 µg/L (well PMW-3-1, the shallowest well in the cluster, was not included in the evaluation, as VC concentrations were below the practical quantitation limit (PQL) of 1.0 µg/L throughout the demonstration).

While VC concentrations were below the MCL of 2 µg/L at more than half of the 18 wells between days 181 and 422 of the demonstration, the data show that degradation continued further downgradient of the designed 20 ft wide biobarrier (beyond the 5-10' wells). Although not presented in the graphs, the data from wells PMW-1S, PMW-1I, and PMW-1D (**Appendix D**), located 8 ft upgradient of the sparge wells (near the upgradient edge of the designed 20 ft wide biobarrier), showed no degradation of VC. As discussed previously for *cis*-DCE, data indicate that the biobarrier created during the demonstration was wider than anticipated (~30 ft compared to 20 ft) and started further downgradient than expected, most likely due to the high rate of groundwater flow and low upgradient DO concentrations. Changes in representative mass flux of VC through and downgradient of the barrier is discussed further in **Section 5.7.2**.

As shown in **Figures 5.36** and **5.37**, VC concentrations increased above baseline at most of the wells during the post treatment sampling event performed on day 517 (105 days after the final propane/ammonia biosparging cycle). Similar order of magnitude increases in VC concentrations were also observed in upgradient background wells BMW-1I (shown on **Figures 5.36** and **5.37**) and BMW-1D by the post treatment sampling event, indicating that VC concentrations entering the study area were increasing throughout much of the demonstration period. As observed with *cis*-DCE, in the absence of oxygen and cometabolic substrate addition (and possibly nutrient addition), the degradative activity of the propane oxidizing bacteria (or other bacteria capable of aerobically degrading VC) that were grown within the treatment zone ceased, and contaminated groundwater flowing through this area was no longer being treated. In the case of VC, oxygen (and possibly methane) may have been most important, as previously described.

5.7.2 Mass Flux Evaluation

To further assess performance of the cometabolic treatment barrier, changes in representative mass flux through and downgradient of the barrier were estimated. The estimates were based on estimated flow rates and measured concentrations at discrete-interval well clusters located near the upstream edge of the barrier (PMW-1S, PMW-1I, PMW-1D, ~8 ft upgradient up biosparge wells, and well clusters located 5, 10, 15, and 25 ft downgradient of the biosparge wells (PMW-X-2, PMW-X-3, and PMW-X-4 where X=0,1,2,3 with increased X located further downgradient) (as shown on **Figure 5.38**). The well clusters were assumed to represent concentrations across vertical planes at each of the 5 distances. Estimated fluxes at the planes also assumed a groundwater seepage velocity of 0.5 ft/day with a representative porosity of 0.3 (**Section 4.2**). Estimates of mass flux were performed for time points when samples were collected at all relevant wells. When samples were below detection limits, concentrations at the respective limits were assumed; this likely resulted in an overestimate of fluxes and an underestimate of mass loss in some cases (i.e., the data are conservative).

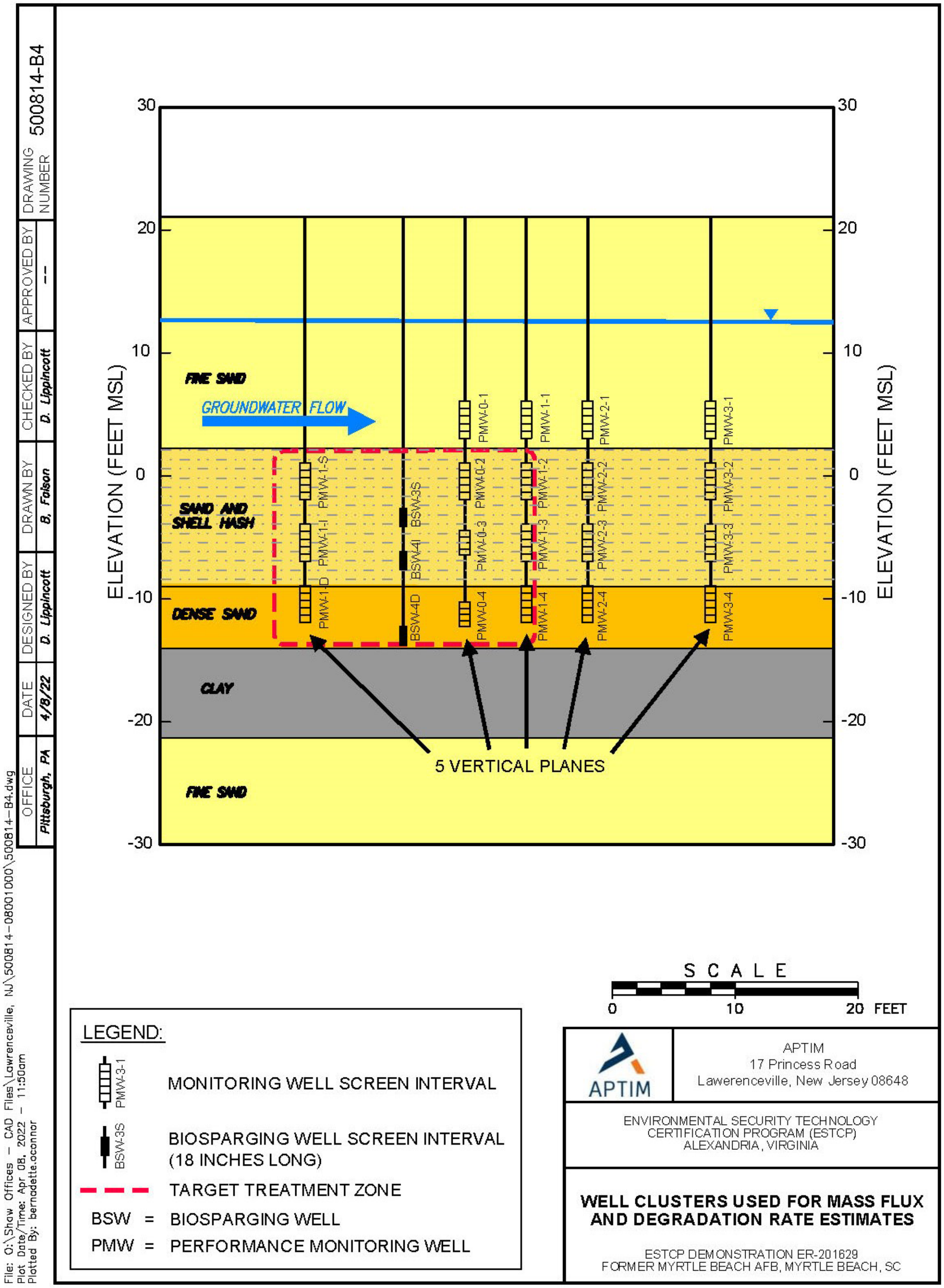


Figure 5.38 Well Clusters Used for Mass Flux and Degradation Rate Estimates

Figure 5.39 shows the change in *cis*-DCE flux through and downgradient of the cometabolic treatment barrier. As discussed above, little degradation of *cis*-DCE was observed prior to day 139 of sparging operations, presumably due to the requirement for biomass growth of propane oxidizing bacteria, as discussed previously. At day 218, decreases in *cis*-DCE mass flux were observed through and downgradient of the biobarrier (**Figure 5.39**), indicating mass loss due to biodegradation. By day 294, this mass loss increased and appeared relatively constant during operations thereafter. As previously discussed, propane addition began on day 68 of the demonstration, upon completion of the oxygen-only biosparging operational phase. Propane fluxes (**Figure 5.40**) at the site were noted to be high at day 139 and decreased approximately tenfold thereafter due to increased biological activity. As discussed in **Section 5.7.3**, propane oxidizing genes were noted to increase by ~1000x between day 50 and day 294 of sparging operations (dissolved propane results are discussed further in **Section 5.7.3**).

Figure 5.41 and **Figure 5.42** show changes in VC and methane fluxes through and downgradient of the biobarrier at the same time points as **Figure 5.39**. As with *cis*-DCE, decreases in the mass fluxes of VC and methane were observed starting at day 218. Even lower fluxes of VC (after treatment) than presented in **Figure 5.41** may have occurred, but due to analytical detections limits (PQL of 1 µg/L), these could not be fully quantified. **Figure 5.43** shows estimated first order degradation rate constants across the biosparging treatment zone, assuming a simple plug-flow model and a constant groundwater seepage velocity of 0.5 ft/day. Some VC and methane degradation were indicated after oxygen sparging started, but before propane oxidizing activity appeared well distributed. This activity can likely be attributed to organisms other than the propane oxidizing bacteria targeted in this work (e.g., methane/ethene oxidizing bacteria), which were noted to increase during the oxygen-only biosparging phase (as discussed in **Section 5.7.9**). After day 218, the estimated rates of *cis*-DCE and VC degradation were similar (up to ~0.08 day^{-1}), which contrasts with expectations based on laboratory batch kinetic studies, where VC degradation was observed to be at least an order of magnitude faster than *cis*-DCE degradation. As noted above, VC degradation may be underestimated due to detection limitations, but differences in microbial community from those studied in the laboratory may also help explain these differences, as could other kinetic limitations, such as transport of relevant chemical species at a variety of scales. This latter explanation may also help explain similarity between *cis*-DCE, VC, and methane degradation rates (**Figure 5.43**). Due to periodic propane sparging during operations, similar analytical approaches for estimating propane utilization were not possible. Repeated observations at well clusters PMW-0-X and PMW-1-X between sparging events prior to presumed increases in activity, however, suggested that propane utilization rates were between 0.1 day^{-1} and 0.3 day^{-1}. Assuming 40-day transport across the biobarrier, the maximum observed field rates would be sufficient to lower *cis*-DCE and VC from the maximum concentrations observed during site characterization activities (133 µg/L and 23.5 µg/L, respectively) to 6 µg/L and 1 µg/L, respectively, both below their MCLs.

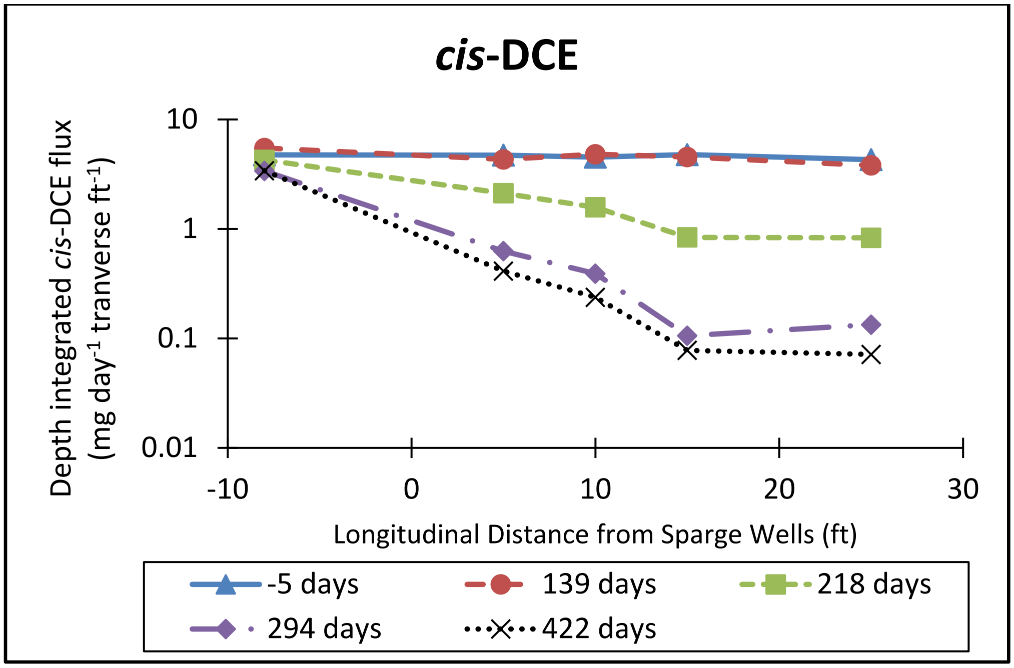


Figure 5.39 Estimated *cis*-DCE Flux Across Five Planes Perpendicular to Flow.

Flux was reasonably constant with distance for at least 139 days after sparging with oxygen started. cis-DCE flux decreased with distance starting by at least 218 days (150 days after propane addition was initiated), and the decrease in flux appeared reasonably constant between 294 and 422 days. Note the logarithmic scale on the Y-axis.

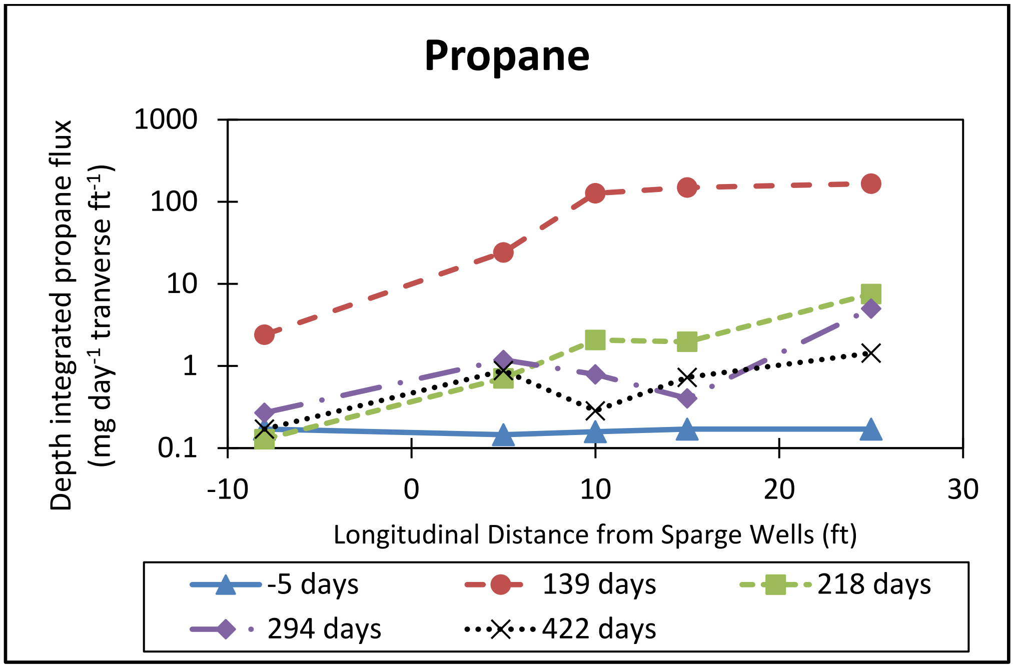


Figure 5.40 Estimated Propane Flux Across Five Planes Perpendicular to Flow.

The highest fluxes represented here occurred at 139 days. After 139 days, total propane fluxes were lower again, likely due to increased consumption of propane by propane oxidizing bacteria. Note the logarithmic scale on the Y-axis.

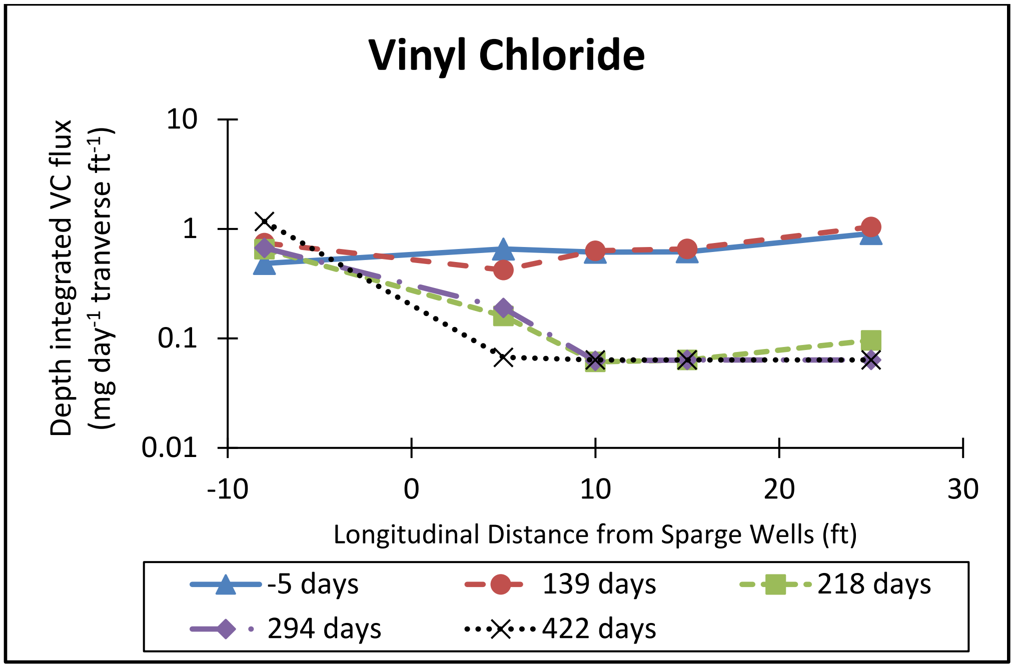


Figure 5.41 Estimated Vinyl Chloride Flux Across Five Planes Perpendicular to Flow.

Vinyl chloride flux decreased with distance starting by at least 218 days. The lowest fluxes indicated (~0.06 mg day^{-1} transverse ft^{-1}) correspond to the detection limits, and it is likely that true fluxes were lower. Note the logarithmic scale on the Y-axis.

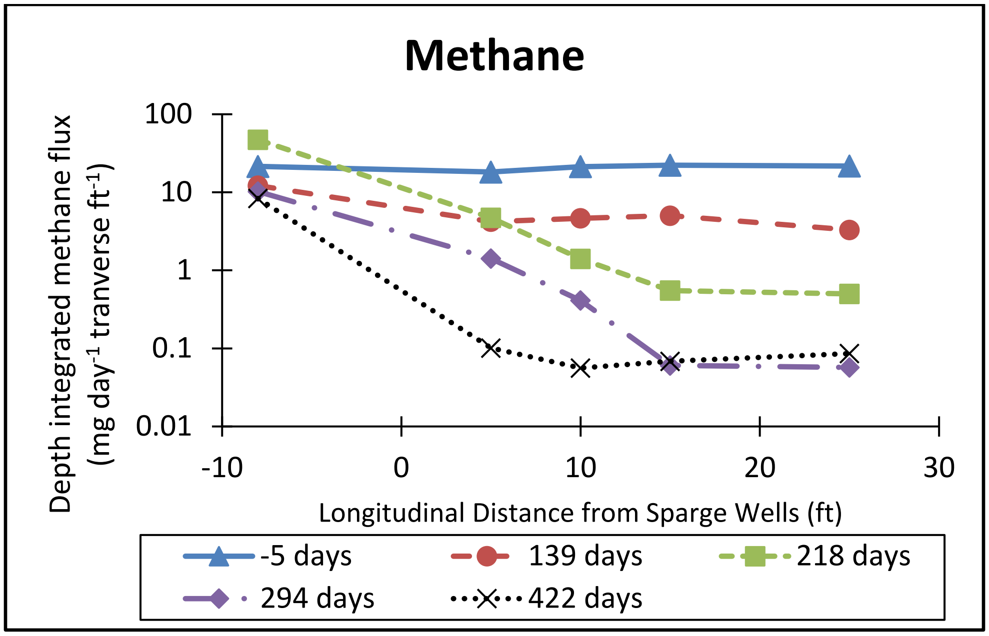


Figure 5.42 Estimated Methane Flux Across Five Planes Perpendicular to Flow.

Although not represented, a decrease in flux with distance downgradient was observed between the start of oxygen sparging and 139 days. At around 139 days, this decrease in flux was smaller, perhaps corresponding to large increase in propane concentrations and inhibition. Methane flux decreased with distance again starting by at least 218 days. Note the logarithmic scale on the Y-axis.

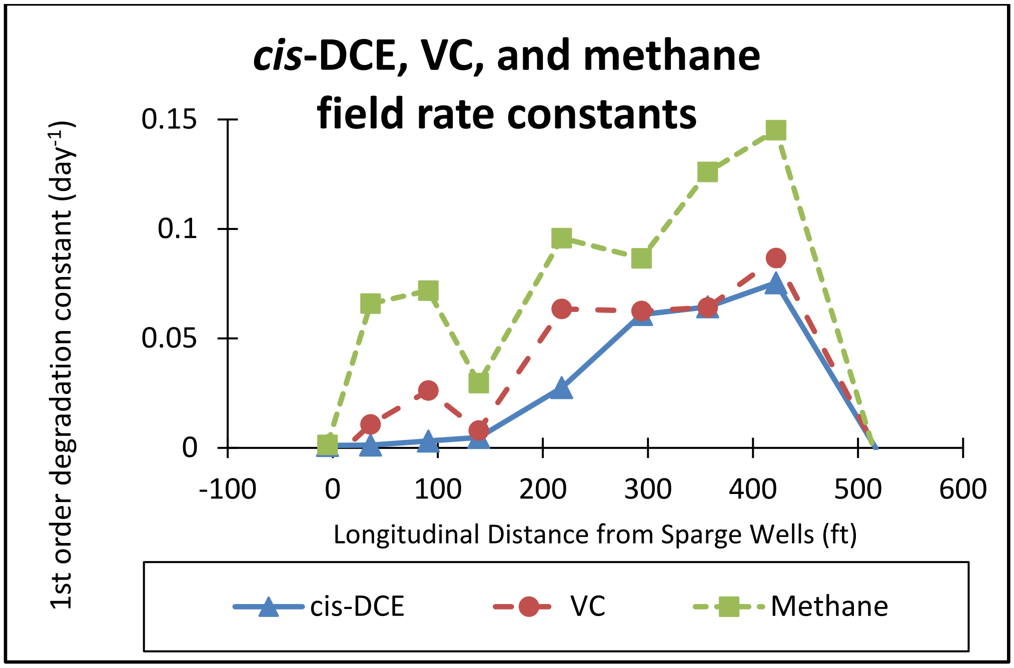


Figure 5.43 Estimated 1st Order Field Rate Degradation Constants for *cis*-DCE, Vinyl Chloride, and Methane Across the Biosparging Treatment Zone.

Estimated constants are based on a simple plug-flow model with changes in flux across the treatment zone and an estimated groundwater velocity of 0.5 ft/day. cis-DCE degradation increased after 139 days, when propane consumption increased. Assessments to estimate propane utilization rates were not possible due to known additions and sources within the treatment zone. VC and methane may have degraded prior to significant activity of propane oxidizing bacteria, with the addition of oxygen at the site. The decreased methane and VC degradation rates at 139 days may indicate inhibition due to elevated propane concentrations.

5.7.3 Dissolved Propane

Groundwater samples were collected and analyzed in the field for dissolved propane at all 27 monitoring wells during baseline, Phase 1, Phase 2, and post treatment monitoring events, as detailed in **Section 5.5** and summarized in **Table 5.8**. Dissolved propane concentrations measured at the 25 performance monitoring wells and one of the two upgradient background wells (BMW-1I) are plotted relative to various distances from the line of biosparging wells in **Figure 5.44**. It should be noted that dissolved propane concentrations measured at the wells were highly dependent on when the sample was collected relative to the previous sparging event, with concentrations generally decreasing with time after sparging occurred. Dissolved propane concentration data are provided in **Appendix D** on a well-by-well basis. Results of the data collected are summarized as follows:

- Dissolved propane was below the detection limit (PQL=2.67 ug/L) at all 27 monitoring wells during baseline sampling (day -5);
- Dissolved propane was measured above the detection limit at one of the three monitoring wells (BMW-1S) located 8' upgradient of the biosparging wells during the demonstration (**Figure 5.44, panel A**), with concentrations reaching up to 110 µg/L;

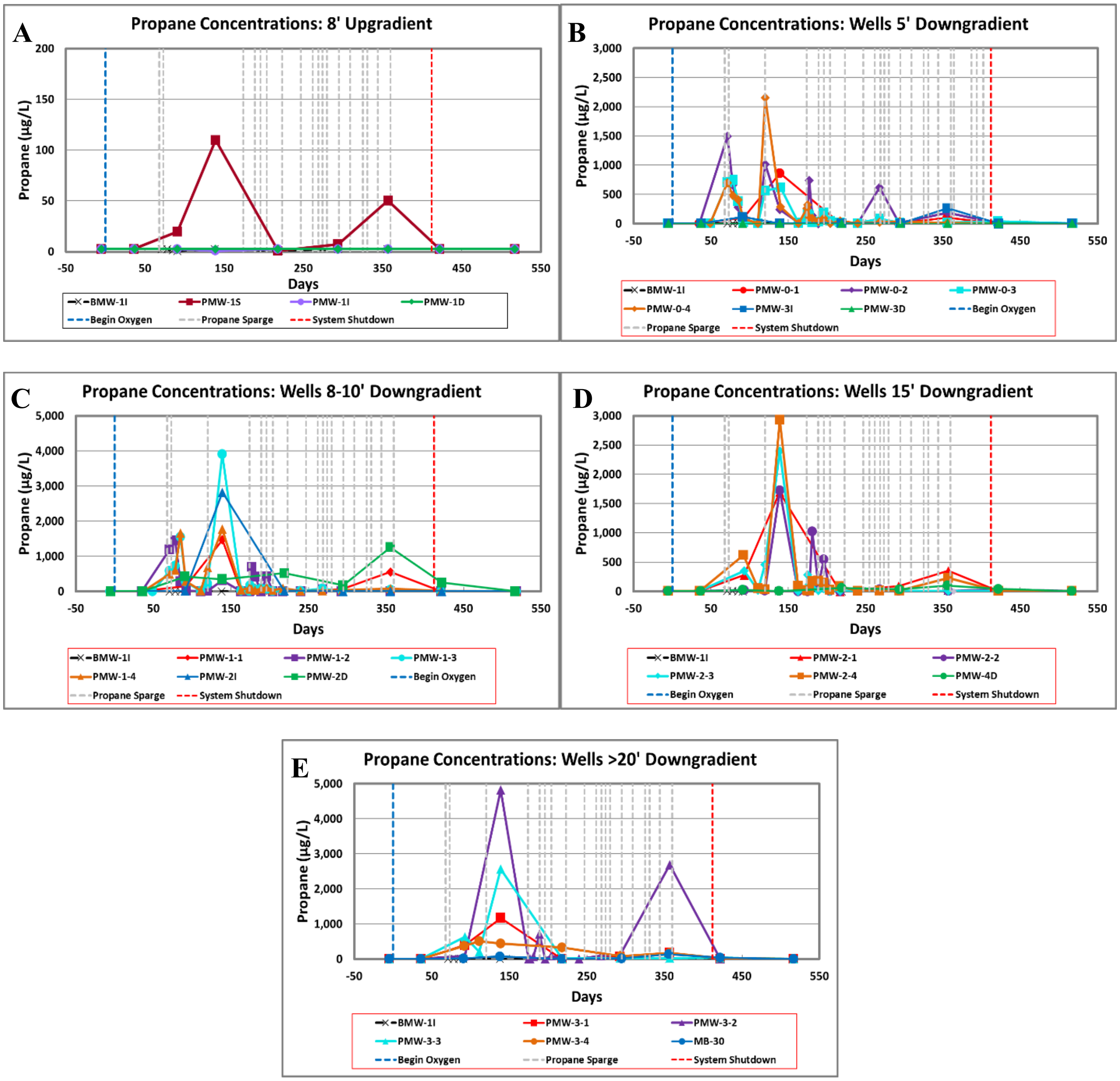


Figure 5.44 Dissolved Propane Plotted by Distance from the Sparge Wells.

Dissolved propane concentrations measured during groundwater sampling events throughout the demonstration are plotted by wells located 8' upgradient (panel A), 5' downgradient (panel B), 8-10' downgradient (panel C), 15' downgradient (panel D), and >20' downgradient (panel E) of the line of biosparging wells.

- Dissolved propane was measured above the 100 µg/L multiple times at 5 of the 6 wells located 5' downgradient of the biosparging wells, with PMW-3D showing the least influence from propane sparging (**Figure 5.44, panel B**). Propane concentrations were generally higher during the first 2.5 months of Phase 2 operation (with concentrations up to 2,156 µg/L measured at PMW-0-4 on day 120), and decreased significantly thereafter as biodegradation rates increased;

- Dissolved propane was measured above the 100 µg/L multiple times at 5 of the 6 wells located 8-10’ downgradient of the biosparging wells, with PMW-2I showing the least consistent influence from propane sparging (**Figure 5.44, panel C**). Propane concentrations were generally higher during the first 2.5 months of Phase 2 operation (with concentrations up to 3,905 µg/L measured at PMW-1-3 on day 139), and decreased significantly thereafter as biodegradation rates increased;
- Dissolved propane was measured above the 100 µg/L multiple times at 4 of the 5 wells located 15’ downgradient of the biosparging wells, with PMW-4D showing the least influence from propane sparging (**Figure 5.44, panel D**). Propane concentrations were generally higher during the first 2.5 months of Phase 2 operation (with concentrations up to 2,928 µg/L measured at PMW-2-1 on day 139), and decreased significantly thereafter as degradation rates increased;
- Dissolved propane was measured above the 100 µg/L multiple times at 4 of the 5 wells located >20’ downgradient of the biosparging wells, with MB-30 showing the least influence from propane sparging (**Figure 5.44, panel E**). Propane concentrations were generally higher during the first 2.5 months of Phase 2 operation (with concentrations up to 4,828 µg/L measured at PMW-3-2 on day 139), and decreased significantly thereafter as degradation rates increased; and
- Dissolved propane concentrations returned to baseline by the post treatment sampling event conducted on day 422.

5.7.4 Dissolved Oxygen

Groundwater samples were collected and analyzed in the field for DO at all 27 monitoring wells during baseline, Phase 1, Phase 2, and post treatment monitoring events, as detailed in **Section 5.5** and summarized in **Table 5.8**. DO concentrations measured at the 25 performance monitoring wells and one of the two upgradient background wells (BMW-1I) are plotted relative to various distances from the line of biosparging wells in **Figure 5.45**. DO concentration data are provided in **Appendix D** on a well-by-well basis. Results of the data collected are summarized as follows:

- Baseline (day -5) DO concentrations ranged between 0.33 mg/L and 0.87 mg/L, indicating that the aquifer was anoxic;
- DO concentrations above the 3 mg/L target were observed at one of the three monitoring wells (BMW-1S) located 8’ upgradient of the biosparging wells during the demonstration (**Figure 5.45, panel A**);
- DO concentrations were regularly measured above the 3 mg/L target at 4 of the 6 wells located 5’ downgradient of the biosparging wells, with PMW-3D showing the least influence from oxygen sparging (**Figure 5.45, panel B**);
- DO concentrations were regularly measured above the 3 mg/L target at 5 of the 6 wells located 8-10’ downgradient of the biosparging wells, with PMW-2I showing the least influence from oxygen sparging (**Figure 5.45, panel C**);
- DO concentrations were regularly measured above the 3 mg/L target at 2 of the 5 wells located 15’ downgradient of the biosparging wells (**Figure 5.45, panel D**), indicating that oxygen was being consumed before reaching these wells;
- DO concentrations were not regularly measured above the 3 mg/L target at any of the 5 wells located >20’ downgradient of the biosparging wells (**Figure 5.45, panel E**), further indicating that oxygen was being consumed before reaching these wells; and

- DO concentrations had returned to baseline during the post treatment sampling event conducted on day 422.

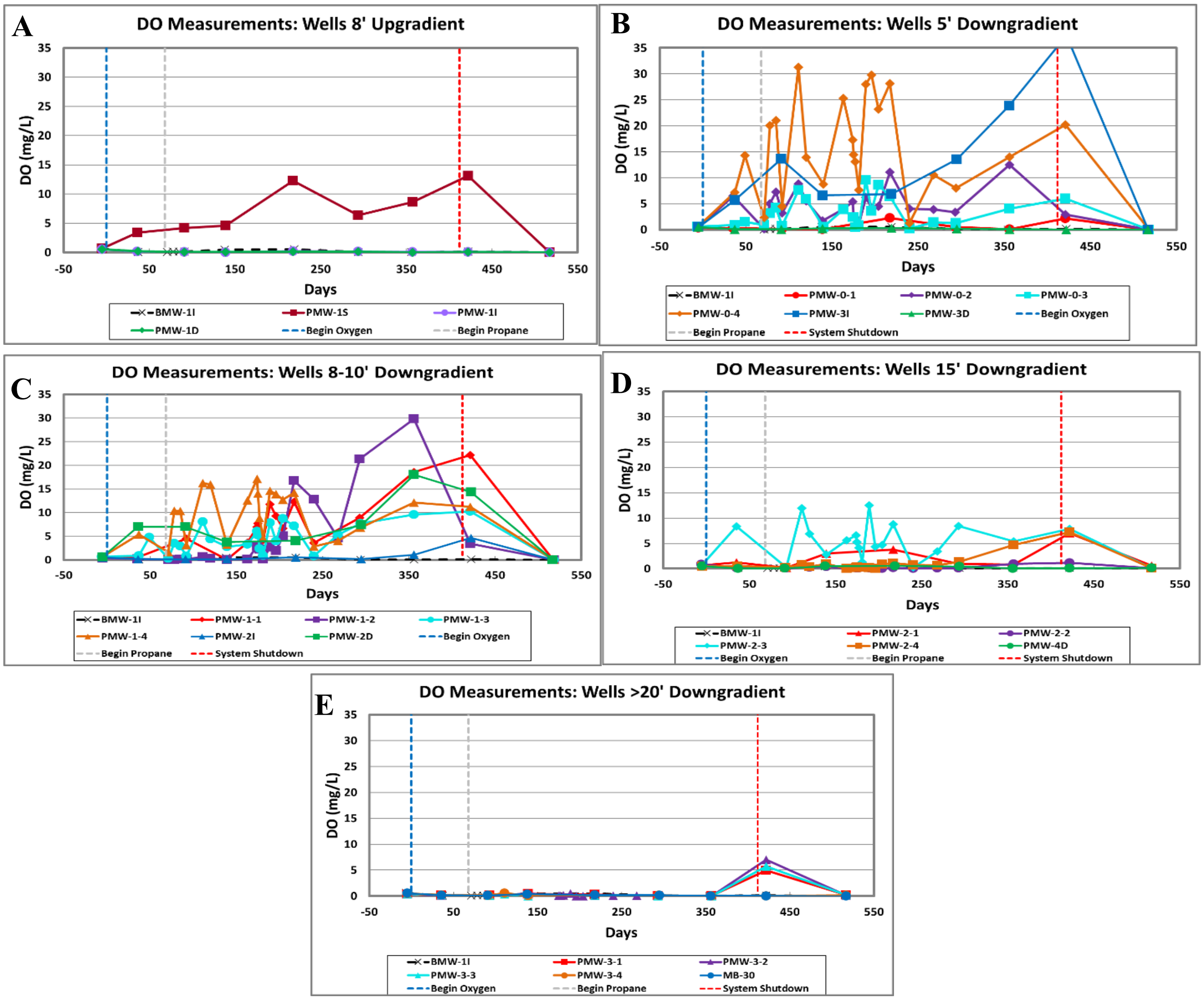


Figure 5.45 Dissolved Oxygen Plotted by Distance from the Sparge Wells.

Dissolved oxygen concentrations measured during groundwater sampling events throughout the demonstration are plotted by wells located 8' upgradient (panel A), 5' downgradient (panel B), 8-10' downgradient (panel C), 15' downgradient (panel D), and >20' downgradient (panel E) of the line of biosparging wells.

5.7.5 ORP

Groundwater samples were collected and analyzed in the field for ORP at all 27 monitoring wells during baseline, Phase 1, Phase 2, and post treatment monitoring events, as detailed in **Section 5.5** and summarized in **Table 5.8**. ORP measurements at the 25 performance monitoring wells and one of the two upgradient background wells (BMW-1I) are plotted relative to various distances from the line of biosparging wells in **Figure 5.46**. ORP measurement data are provided in **Appendix D** on a well-by-well basis. Results of the data collected are summarized as follows:

- Baseline ORP concentrations ranged between -84.0 millivolts (mV) and -121.2 mV, indicating conditions in the aquifer were moderately reducing;

- Significant increases in ORP were observed at one of the three monitoring wells (BMW-1S, with an increase up to 283 mV) located 8’ upgradient of the biosparging wells during the demonstration (**Figure 5.46, panel A**);
- Increases in ORP to between ~140 mV and 280 mV were observed at 5 of the 6 wells located 5’ downgradient of the biosparging wells, with PMW-3D showing the least influence from oxygen sparging (**Figure 5.46, panel B**);
- Increases in ORP to between ~160 mV and 270 mV were observed at the 6 wells located 8-10’ downgradient of the biosparging wells (**Figure 5.46, panel C**);

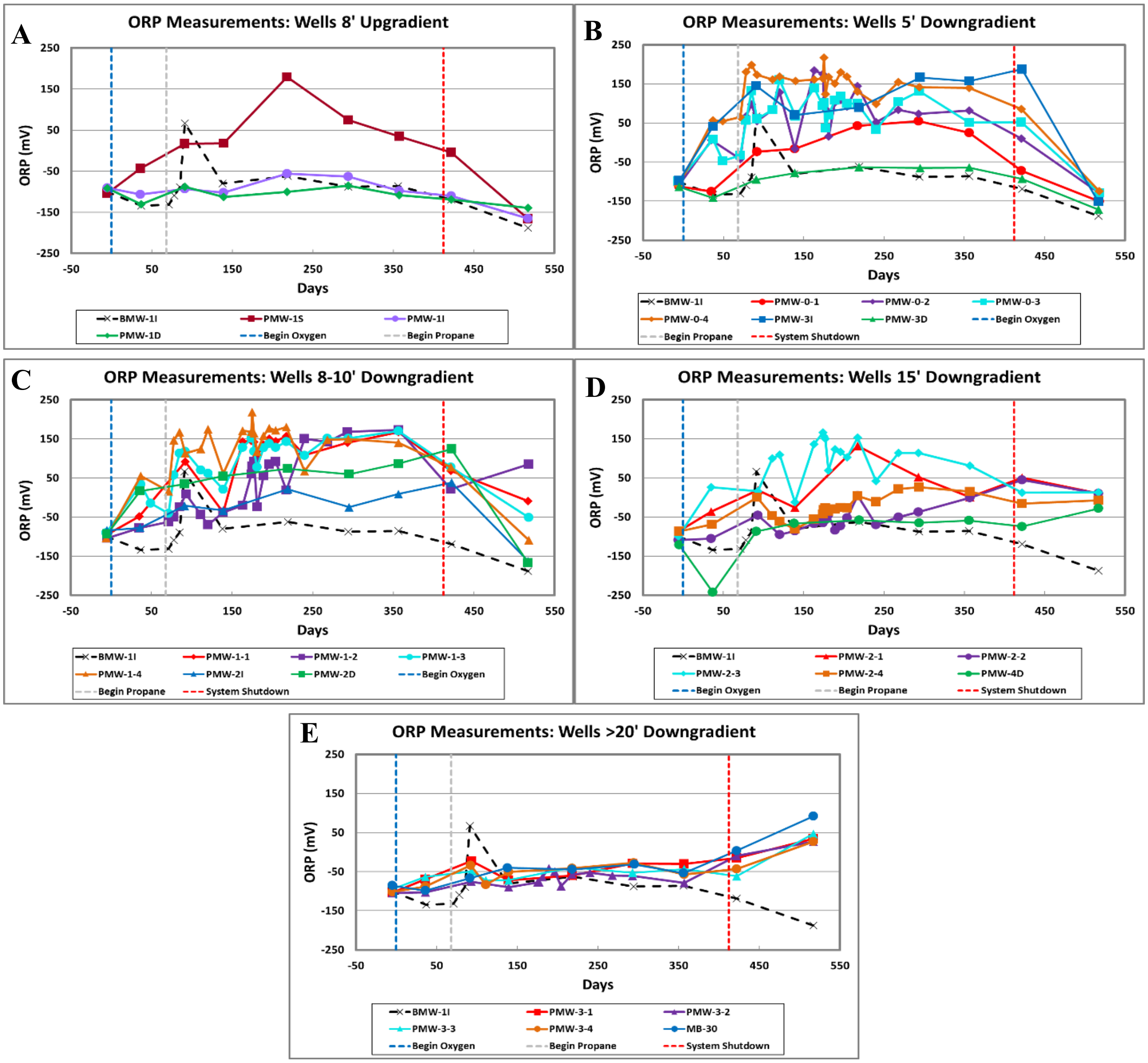


Figure 5.46 ORP Plotted by Distance from the Sparge Wells.

ORP measurements during groundwater sampling events throughout the demonstration are plotted by wells located 8’ upgradient (panel A), 5’ downgradient (panel B), 8-10’ downgradient (panel C), 15’ downgradient (panel D), and >20’ downgradient (panel E) of the line of biosparging wells.

- Increases in ORP to between ~90 mV and 250 mV were observed at the 5 wells located 15’ downgradient of the biosparging wells (**Figure 5.46, panel D)**;
- Increases in ORP to between ~50 mV and 90 mV were observed at the 5 wells located >20’ downgradient of the biosparging wells (**Figure 5.46, panel E**);
- ORP data indicate that conditions were generally oxidizing within the biobarrier, and significantly less reducing downgradient of the biobarrier, during Phases 1 and 2 of the demonstration;
- ORP had largely returned to baseline levels within the biobarrier during the final performance sampling event (**Figure 5.46, Panels A, B** and **C**); and
- ORP levels were relatively stable at wells located 15’ downgradient and were still increasing at wells located >20’ downgradient of the biobarrier during the post treatment sampling event conducted on day 422 (**Figure 46, panels D** and **E**).

5.7.6 Total Ammonia and Nitrate

Groundwater samples were collected and analyzed for total ammonia and nitrate at all 27 monitoring wells during baseline, Phase 1, Phase 2, and post treatment monitoring events, as detailed in **Section 5.5** and summarized in **Table 5.8**. Total ammonia and nitrate concentration data are provided in **Appendix D** on a well-by-well basis. Results of the data collected are summarized as follows:

- Baseline total ammonia concentrations ranged between 0.077 mg/L and 0.217 mg/L;
- Total ammonia concentrations generally decreased at the 22 monitoring wells downgradient of the biosparging wells during Phases 1 and 2, with the exception of transient increases observed at wells PMW-1-2, PMW-1-3, PMW-2-2, PMW-2-3, PMW-3-2, and PMW-3-3 (with a maximum concentration of 18.5 mg/L in PMW-1-2), and returned to near baseline levels during the post treatment sampling event (day 518);
- Baseline nitrate concentrations were below the PQL of 0.20 mg/L at all wells;
- Nitrate concentrations were generally below the PQL of 0.20 mg/L throughout the demonstration, with the exception of transient increases observed at wells PMW-2-3 and PMW-3-3 (with a maximum concentration of 0.93 mg/L at PMW-2-3); and
- Total ammonia and nitrate data collected during the demonstration suggest that the ammonia sparged into the aquifer during Phase 2 operations (67.6 lbs., as detailed in **Section 5.5.3**) was rapidly assimilated by bacteria within the aquifer and confirms results of the microcosm studies (**Section 5.3.1**) suggesting that inorganic nitrogen will limit the growth of cometabolic bacteria if not supplied along with propane to the aquifer.

5.7.7 Sulfate

Groundwater samples were collected and analyzed for sulfate at all 27 monitoring wells during baseline, Phase 1, Phase 2, and post treatment monitoring events, as detailed in **Section 5.5** and summarized in **Table 5.8**. Sulfate concentration data are provided in **Appendix D** on a well-by-well basis. Sulfate concentration data at the 6 performance monitoring wells located between 8-10’ downgradient of the biosparging wells, and one of the two upgradient background wells (BMW-1I), are plotted in **Figure 5.47.** Results of the data collected are summarized as follows:

- Baseline sulfate concentrations ranged between 16.0 mg/L and 34.4 mg/L;
- Sulfate concentrations generally increased an order of magnitude (up to a maximum of 551 mg/L at PMW-2-4) at the 22 monitoring wells downgradient of the biosparging wells during Phases 1 and 2, with the exception of relatively stable concentrations observed at PMW-1I, PMW-ID, and PMW-3D;
- Sulfate concentrations returned to baseline levels during the post treatment sampling event (day 518); and
- Increased sulfate concentrations observed during Phases 1 and 2, when regular oxygen sparging was occurring, indicate significant oxidation of sulfide and sulfide-containing minerals within the treatment zone. This is consistent with re-oxidation of the aquifer.

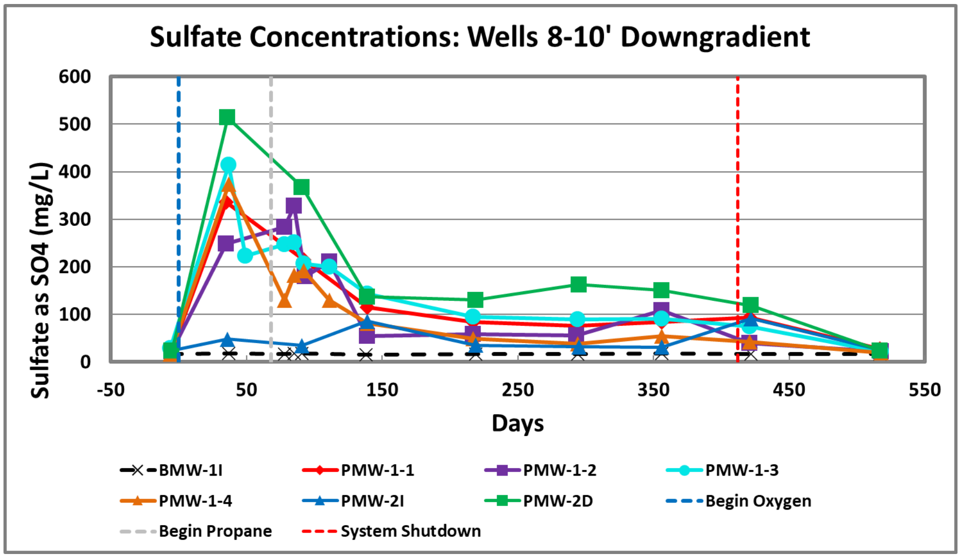


Figure 5.47 Sulfate Concentrations at Wells located 8-10' Downgradient of the Sparge Wells.

5.7.8 Dissolved Methane

Groundwater samples were collected and analyzed for dissolved methane at all 27 monitoring wells during baseline, Phase 1, Phase 2, and post treatment monitoring events, as detailed in **Section 5.5** and summarized in **Table 5.8**. Methane concentration data are provided in **Appendix D** on a well-by-well basis. Dissolved Methane concentration data at the 6 performance monitoring wells located between 8-10'downgradient of the biosparging wells, and one of the two upgradient background wells (BMW-1I), are plotted in **Figure 5.48.** Results of the data collected are summarized as follows:

- Baseline methane concentrations ranged between 104 mg/L and 461 mg/L;
- Dissolved methane concentrations generally decreased one to two orders of magnitude (to below the PQL of 0.95 ug/L in some cases) at the 22 monitoring wells downgradient of the biosparging wells during Phases 1 and 2;
- Dissolved methane concentrations returned to baseline levels during the post treatment sampling event (day 518); and

- The decrease in dissolved methane concentrations observed during Phases 1 and 2, when regular oxygen sparging was occurring, can likely be attributed to an increase in methanotrophic organisms and activity, which were noted to increase during the oxygen-only biosparging phase (as discussed in **Section 5.7.9**).

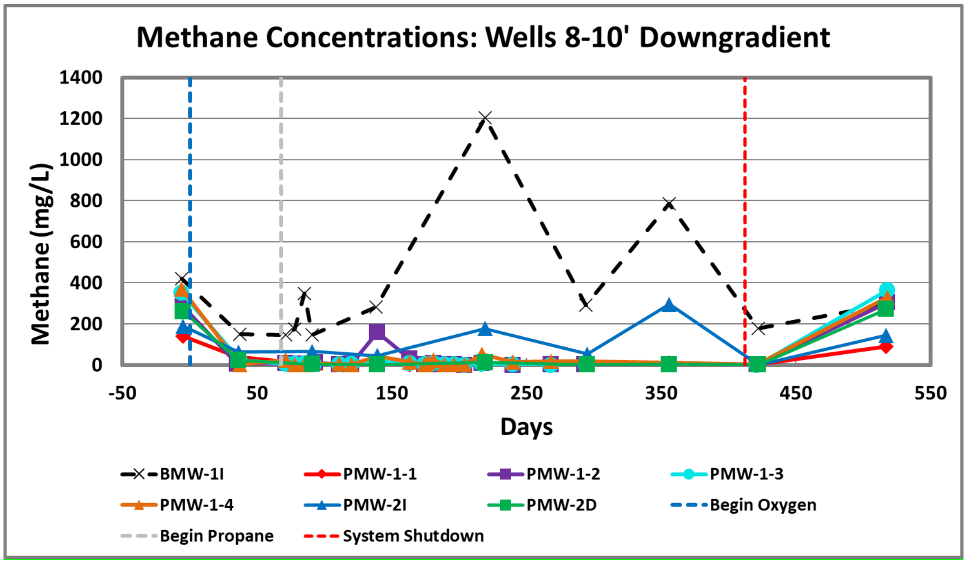


Figure 5.48 Dissolved Methane Concentrations at Wells located 8-10' Downgradient of the Sparge Wells.

5.7.9 Cometabolic Organisms/Genes

Quantification of target cometabolic organisms/genes by qPCR was performed on groundwater samples collected at four select monitoring wells (downgradient monitoring wells PMW-0-3, PMW-0-4, PMW-1-3, and background well BMW-1D) once during baseline, once during Phase 1, and twice during Phase 2 (with the second event occurring 9 days after system shutdown). An additional sample was collected at PMW-0-3 during the post treatment sampling event, as detailed in **Section 5.5** and summarized in **Table 5.8**. Microbial data are provided in **Appendix D** on a well-by-well basis and plotted in **Figure 5.49**. Results of the data collected are summarized as follows:

- The concentration of organisms containing the sMMO enzyme increased by 2-3 orders of magnitude at the three downgradient wells during Phase 1 when DO and methane were both present, and generally decreased to near baseline numbers during Phase 2 operations as dissolved methane concentrations decreased;
- The concentration of organisms containing the EtnE enzyme increased by 1-3 orders of magnitude at the three downgradient wells during either Phase 1 or Phase 2 of the demonstration;
- The concentration of organisms containing the PPO and SCAM enzymes increased by 3-4 orders of magnitude at the three downgradient wells during Phase 2, when DO and dissolved propane were both present; and

- The concentration of organisms containing the EtnE, PPO and SCAM enzymes remained relatively consistent (within an order of magnitude), while the cell counts of organisms containing the sMMO enzyme decreased over 2 orders of magnitude, at background well BMW-1D during the demonstration.

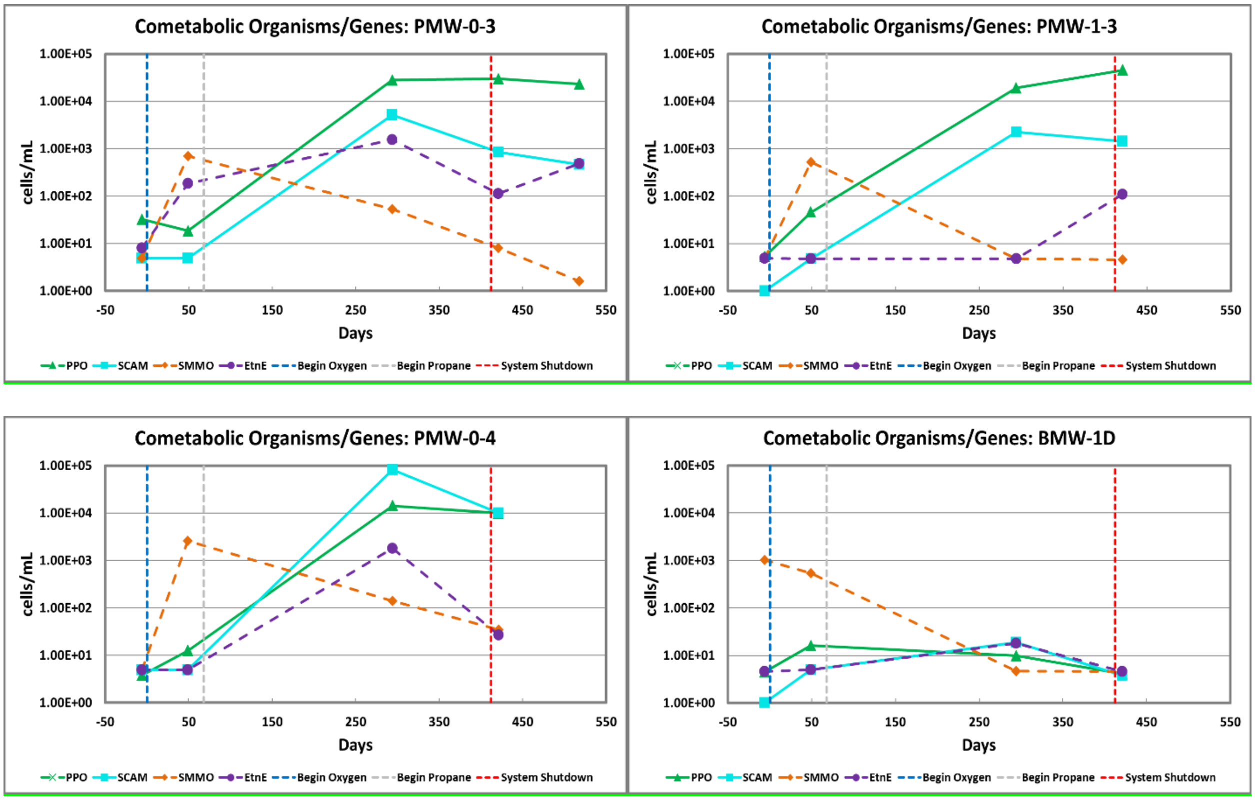


Figure 5.49 Cometabolic Organisms/Genes Quantified During the Demonstration

5.7.10 Water Levels

Groundwater elevation measurements were collected at all 27 monitoring wells during baseline, Phase 1, Phase 2, and post treatment monitoring events, as detailed in **Sections 5.5** and **5.6.1**. Depth to water measurements are provided in **Appendix D** on a well-by-well basis. Baseline groundwater elevation data collected on July 20, 2019 were used to generate the groundwater elevation map presented in **Figure 5.50**. Results of the groundwater elevation data collected are summarized as follows:

- Groundwater contours indicate that the general direction of groundwater flow in the shallow aquifer is to the east-southeast (**Figure 5.50**), indicating that the biobarrier was installed relatively (within ~10 degrees) perpendicular to groundwater flow;
- The hydraulic gradient across the site was calculated to be 0.0222, which is consistent with the historic groundwater gradient discussed in **Section 4.2**;
- Groundwater flow direction and gradient was relatively consistent during the demonstration; and
- Groundwater elevations fluctuated by only ~1.2 ft during the demonstration.

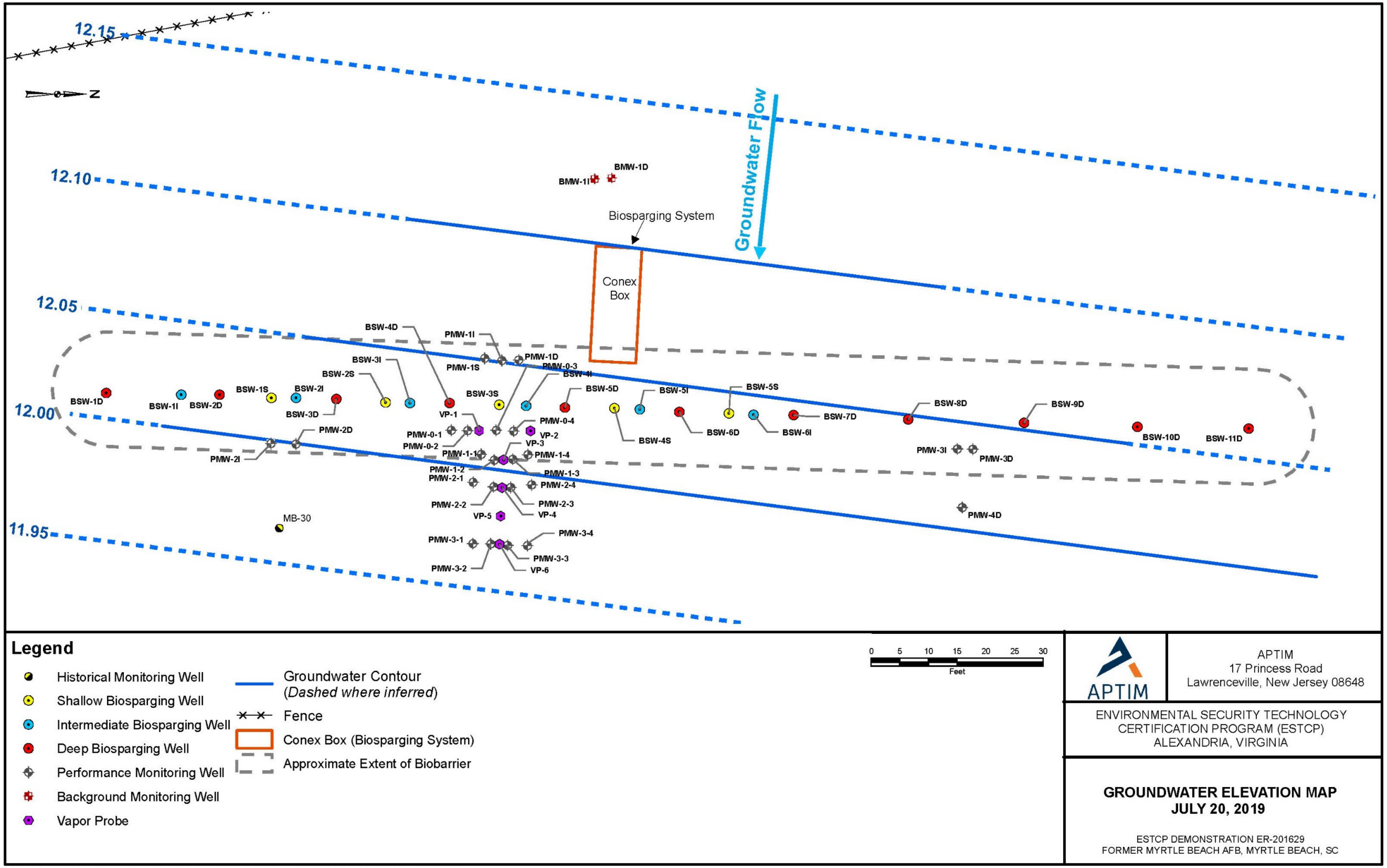


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Figure 5.50 Groundwater Elevation Map: July 20, 2019

5.7.11 Vapor Probes

Vapor probes VP-1 through VP-4 (**Figure 5.10)** were monitored to assess any potential sparge gas migration into the vadose zone during the demonstration. Gas samples were collected once during baseline, twice during Phase 1, and twice during Phase 2 operations. Gas samples were analyzed in the field for VOCs (ppmv), oxygen (percent), hydrogen sulfide (ppmv), carbon monoxide (ppmv), and percent LEL using a PID and combustible gas meter, a detailed in **Section 5.6.3**. Results of the data collected are summarized as follows:

- VOCs: Baseline readings were all 0.0 ppmv; Phase 1 reading ranged between 0.0 ppmv and 0.6 ppmv; and Phase 2 readings ranged between 0.0 ppmv and 1.6 ppmv;
- Oxygen: Baseline readings ranged between 19.9% and 20.2%; Phase 1 reading ranged between 19.4% and 19.9%; and Phase 2 readings ranged between 15.4% and 21.6%;
- Hydrogen Sulfide: Baseline, Phase 1, and Phase 2 readings were all 0.0 ppmv;
- Carbon Monoxide: Baseline, Phase 1, and Phase 2 readings were all 0.0 ppmv; and
- Percent LEL: Baseline and Phase 1 readings were all 0.0 ppmv; Phase 2 readings ranged between 0.0% and 8.0%;

The above readings indicated that the sparging of oxygen, propane, ammonia, and nitrogen gases had limited impact on the gas concentrations within the vadose zone during the demonstration.

5.7.12 System O&M

Biosparging system O&M during Phase 1 and Phase 2 are discussed in detail in **Sections 5.5.2** and **5.5.3**. System O&M primarily consisted of regular (every 2-4 weeks) system checks (to collect manual system pressure and flow data, perform regular system maintenance, and perform leak checks) and changeout of the oxygen 16-packs approximately every 2-3 months. System operations data (gas flows, pressures, cycle frequencies, and downtime) and DO data collected from the four dedicated RDO probes were recorded and stored in data files by the SCADA system on the system laptop. Results of system O&M are summarized as follows:

- The off-the grid solar power system provided consistent power to the biosparging system throughout the entire 518 days of the demonstration, and only required changes to the angles of the solar panel arrays 2 times (winter of 2019, and spring of 2020). Each of these changes were accomplished in less than 1 hour;
- System checks were typically performed in under 3 hours;
- Changeout of the oxygen and nitrogen 16-packs were typically performed in under 4 hours, and required the use of an off-road forklift;
- The 6 tanks of liquified propane and 4 tanks of liquified ammonia did not require replacement during the demonstration;
- Remote communication with the system and the logging capabilities of the SCADA system significantly reduced the number of site O&M visits required. However, additional trips to the site (approximately 5 times during the demonstration) were required to reset the computer or Wi-Fi after remote communication was lost; and
- No major system or equipment failures were experienced during the demonstration.

6.0 PERFORMANCE ASSESSMENT

Performance objectives were established for this demonstration to provide a basis for evaluating the use of cometabolic biosparging for the treatment of a large, dilute cVOC plume. The performance objectives are provided in **Table 3.1** and discussed in **Sections 3.1** to **3.6** in this document. The data for each given objective are provided in **Section 5.7** and **Appendix D**. As summarized in **Section 3.0**, all the critical performance objectives for this demonstration were achieved. The following subsections provide a summary and assessment of the data supporting the performance objectives.

6.1 DETERMINE TREATMENT EFFECTIVENESS

One of the primary objectives of this demonstration was to assess the long-term effectiveness of applying aerobic cometabolism to treat low concentrations of cVOCs across the width of a plume. Understanding the extent to which the target contaminant mass has been removed, and the subsequent impact on groundwater quality, was critical in this evaluation.

As detailed in **Section 5.7.1**, significant decreases in *cis*-DCE and VC were observed starting approximately 2.5 to 3 months after initiating propane and ammonia biosparging, after sufficient biomass growth had occurred within the aquifer. Decreases in *cis*-DCE concentrations were observed in 20 of the 22 wells located within and downgradient of the biobarrier, with concentrations at all 22 wells consistently below the MCL of 70 µg/L between days 181 and 422 of the demonstration. A significant decrease in *cis*-DCE mass flux was observed through and downgradient of the biobarrier by Day 218 (**Section 5.7.2** and **Figure 5.39**), confirming mass loss due to biodegradation. By day 294, this mass loss increased further and appeared relatively constant during operations thereafter. The estimated decline in the mass flux of *cis*-DCE was ~ 70-fold due to barrier operation from day 294 to the end of the study. There were no significant decreases in *cis*-DCE concentrations observed at wells PMW-3D and PMW-4D during Phase 2 of the demonstration, which was likely because target dissolved propane and DO concentrations were not achieved at these locations during this phase (as discussed in **Sections 5.7.3** and **5.7.4**)

VC concentrations were below the MCL of 2 µg/L at 15 of the 18 wells by day 294 and remained low for the remainder of the field demonstration. Decreases in the mass fluxes of VC and methane were observed starting at day 218. Even lower fluxes of VC (after treatment) than presented in **Figure 5.41** may have occurred, but due to analytical detections limits (PQL of 1 µg/L), these could not be fully quantified. VC concentrations remained below the MCL at 16 of the 18 wells during the final performance sampling event conducted on day 422.

The average *cis*-DCE and VC concentrations measured at wells located 25 ft downgradient of the sparge wells during baseline sampling (day -5) and the final performance monitoring event (day 422) showed a 98% and a 92% decrease, respectively (**Figure 5.35)**. *cis*-DCE and VC generally returned to near baseline concentrations (or in the case of VC, higher than baseline) within 105 days after system shutdown due to the absence of oxygen and cometabolic substrate addition (and possibly nutrient addition), as the degradative activity of the propane oxidizing bacteria (or other bacteria capable of aerobically degrading VC) that were grown within the treatment zone ceased, and contaminated groundwater flowing through this area was no longer being treated.

6.2 MAINTAIN AEROBIC CONDITIONS WITHIN THE TREATMENT ZONE

Maintaining aerobic conditions within the treatment zone was critical, as cometabolism using an alkane/alkene gas substrate is an aerobic process. Therefore, oxygen distribution (both vertically and horizontally) within the treatment zone was important to the overall success of the remedial approach. This was particularly true in the area where the demonstration was conducted, which was anoxic and reducing prior to oxygen addition.

As detailed in **Section 5.7.4**, DO concentrations above the 3 mg/L target were observed in most of monitoring wells located within the biobarrier during Phases 1 and 2 of the demonstration (**Figure 5.45**). However, some wells (PMW-2I and PMW-3D) were not significantly impacted by oxygen sparging, and oxygen concentrations dropped rapidly due to the high oxygen demand (both mineral and biological) in the aquifer. Upon full examination of the combined contaminant and geochemical data (including the general lack of DO immediately downgradient of the biobarrier), it was determined that additional oxygen sparging (either frequency or duration), could have extended the treatment zone further downgradient, and potentially improved degradation at the few wells that were only partially impacted. However, considering aquifer heterogeneity, the objective of obtaining and maintaining bulk aerobic conditions in the aquifer was clearly achieved.

6.3 OPTIMIZE PROPANE GAS AMENDMENT DELIVERY MASS AND FREQUENCY

Optimization of propane amendment (mass and sparge frequency) is required to supply enough substrate for biological growth, while ensuring that high dissolved propane concentrations do not lead to continuous competitive inhibition. Therefore, the extent to which propane gas could be distributed (both vertically and horizontally) and dissolved propane subsequently biodegraded within the treatment zone over a period were important to the overall success of the remedial approach.

As detailed in **Section 5.7.4**, dissolved propane was measured above the 100 µg/L consistently at multiple wells within the biobarrier during Phase 2 of the demonstration. The data showed that propane concentrations were generally higher during the first 2.5 months of Phase 2 operation (with concentrations measured more than 2 mg/L in several wells) and decreased significantly thereafter as biodegradation rates increased. As detailed in **Section 5.7.2**, propane fluxes (**Figure 5.40**) at the site were noted to be high at day 139 and decreased approximately tenfold thereafter due to increased biological activity. As discussed in **Section 5.7.3**, propane oxidizing genes were noted to increase by ~1000x between day 50 and day 294 of sparging operations. The data show that a propane sparging frequency of approximately once every 1 to 2 weeks (with average mass loading of ~1.5 lbs./day) was optimal in maintaining biological growth/activity without leading to continuous competitive inhibition.

6.4 DETERMINE SPARGE SYSTEM RELIABILITY

Reliability of biosparging system operation is an important performance objective, as the regular injection of gaseous amendments is critical to the treatment effectiveness of any cometabolic biosparging system. Additionally, reliable performance minimizes system operating costs.

As detailed in **Section 5.7.12**, the off-the grid solar power system provided consistent power to the biosparging system throughout the entire 518 days of the demonstration and only required changes to the angles of the solar panel arrays 2 times (winter of 2019, and spring of 2020), with each of these changes accomplished in less than 1 hour. The system operated as designed, and there no major system or equipment failures were experienced during the demonstration.

6.5 EASE OF USE

The level of effort needed to maintain the cometabolic biosparging system was assessed during the demonstration. Ease of use and low maintenance is critical to the long-term effectiveness of this approach.

As detailed in **Section 5.7.12**, system O&M requirements, which primarily consisted of regular system checks and changeout of the oxygen 16-packs, were not significant during the demonstration. System checks (which entailed collecting manual system pressure and flow data, performing regular system maintenance, and performing leak checks) were generally performed every 2-3 weeks in under 3 hours per visit. Change out of the oxygen 16-packs was conducted approximately every 2-3 months and was typically performed in under 4 hours. The 6 tanks of liquified propane and 4 tanks of liquified ammonia did not require replacement during 12 months of Phase 2 cometabolic biosparging due to the general efficiency of this approach. The ability to communicate remotely with the system (and adjust gas sparging), as well as programmed logging capabilities of the SCADA system significantly reduced the number of site visits required.

In addition to the PI and project engineer, two field technicians were trained to conduct system O&M in one day. Site checks and cylinder changeouts were typically performed by a single technician, with O&M requirements being significantly lower than more active remediation technologies, such as P&T. Furthermore, other the groundwater sampling purge water, there was no waste generated with during application of this *in situ* technology.

7.0 COST ASSESSMENT

7.1 COST MODEL

In order to evaluate the cost of a potential cometabolic biosparging system to treat a full-scale large, dilute CVOC plume, and compare it against other remedial approaches, costs associated with various aspects of the demonstration were tracked throughout the course of the project. **Table 7.1** summarizes the various cost elements and total cost of the demonstration project. The costs have been grouped by categories as recommended in the Federal Remediation Technologies Roundtable Guide to Documenting Cost and Performance for Remediation Projects (FRTR, 1998). Many of the costs shown in this table are a product of the innovative and technology validation aspects of this project and would not be applicable to a typical site application. Therefore, a separate "discounted costs" column that excludes or appropriately discounts these costs has been included in **Table 7.1** to provide a cost estimate for implementing this technology at the same scale as the demonstration (i.e., pilot scale).

Costs associated with the demonstration were tracked from October 2016 to April 2022. The total cost of the demonstration was \$1,398,612 which included \$598,964 in capital costs, \$256,156 in O&M costs, and \$543,491 in demonstration-specific costs (cost related to ESTCP-specific requirements, site selection, and site characterization/testing).

7.1.1 Capital Costs

Capital costs (primarily system design and installation) accounted for \$598,964 (or 43%) of the total demonstration costs. As indicated in **Table 7.1**, these costs exceed what would be expected (the discounted cost) during a typical remediation project due to the innovative nature of the technology and the associated complexity of the system design and fabrication/installation.

7.1.2 O&M Costs

O&M costs accounted for \$256,156 (or 18%) of the total demonstration cost. These costs consisted primarily of groundwater monitoring (including analytical) and system O&M. System O&M costs were \$110,241, or 8% of the total demonstration cost. Extensive performance monitoring activities were conducted to effectively validate this technology including 1 full baseline performance monitoring event, 9 Phase 1 performance monitoring events (including 7 DO monitoring rounds, 1 full performance monitoring round, and 1 pre-substrate round), 21 Phase 2 performance monitoring events (including 6 full performance monitoring rounds and 15 propane and ammonia monitoring rounds), and 1 full post-treatment monitoring event.

7.1.3 Demonstration-Specific Costs

Other demonstration-specific costs (costs not expected to be incurred during non-research-oriented remediation projects) accounted for approximately \$543,491 (or 39%) of the total demonstration cost. These costs included site selection, site characterization and sparge testing, laboratory microcosm and column testing, ESTCP demonstration reporting and meeting (Interim Progress Report) requirements, technology transfer efforts, and preparation of an extensive final technical and cost report.

Table 7.1. Demonstration Cost Components

Cost Element	Details	Tracked Demonstration Costs	Discounted Costs[1]
	CAPITAL COSTS		
System Design	Labor	$71,301	$50,000
	Subcontracts (gas delivery technical support)	$18,286	$0
System Installation (sparge and monitoring well installation, surveying, sparge system with controls, piping, trenching, system materials)	Labor	$149,509	$100,000
	Travel	$11,545	$0
	Equipment & Materials	$61,032	$40,000
	Subcontracts (driller, surveyor, system install)	$287,290	$200,000
	Subtotal	**$598,964**	**$390,000**
	OPERATION AND MAINTENANCE COSTS		
Groundwater Sampling	Labor	$47,478	$30,000
	Equipment & Materials	$2,944	$1,500
	In-House Analytical (labor and materials)	$47,785	$0
	Outside Analytical	$9,686	$30,000
	Subcontracts (sampling)	$38,022	$20,000
System O&M (including testing & start-up)	Labor	$54,082	$40,000
	Equipment & Materials	$36,451	$25,000
	Subcontracts (system O&M)	$19,708	$15,000
	Subtotal	**$256,156**	**$161,500**
	OTHER TECHNOLOGY-SPECIFIC COSTS		
Site Selection	Labor	$19,572	$0
	Travel	$745	$0
Site Characterization (DPT investigation)	Labor (including in-house analytical)	$50,033	$0
	Travel	$1,863	$0
	Materials	$2,362	$0
	Subcontractor (driller)	$39,589	$0
Microcosm and Column Testing	Labor (including in-house analytical)	$97,077	$50,000
	Materials	$694	$500
Test Well Installation and Sparge Testing	Labor (including in-house analytical)	$93,839	$60,000
	Travel	$10,921	$0
	Materials	$6,635	$4,000
	Subcontractor (driller)	$32,856	$25,000
System and Well Decommissioning	Labor	$11,531	$10,000
	Materials	$81	$0
	Subcontractor (system decom & waste disposal)	$9,769	$7,500
Quarterly Reporting & IPR/Project Meetings	Labor	$58,971	$0
	Travel	$1,247	$0
	Materials	$64	$0
Technology Transfer (presentations, papers)	Labor	$19,772	$0
	Travel	$6,132	$0
Demonstration Plan/Work Plan	Labor	$51,839	$25,000
Final Report	Labor	$27,899	$20,000
	Subtotal	**$543,491**	**$202,000**
	TOTAL COSTS	**$1,398,612**	**$753,500**

Notes:

[1] Discounted costs are defined as estimated costs to implement this technology at the same scale as the demonstration. These costs do not include the technology validation apects of this ESTCP demonstrations, such as site selection, treatability studies, extensive groundwater sampling, ESTCP demonstration reporting and meeting (IPR) requirements, and preparation of technical and cost and performance reports.

7.2 COST DRIVERS

The expected cost drivers for installation and operation of a cometabolic biosparging system to treat a full-scale large, dilute CVOC plume, and those that will determine the cost/selection of this technology over other options, include the following:

- Depth of the plume bgs;
- Width, length, and thickness of the plume;
- Aquifer lithology and hydrogeology;
- Passive and sustainable power (solar);
- Length of time for clean-up (e.g., necessity for accelerated clean-up);
- The presence of indigenous bacteria capable of cometabolically degrading cVOCs;
- Concentrations of contaminants and alternate electron acceptors (e.g., nitrate [NO_3^-], sulfate [SO_4^{2-}], and O_2); and
- Presence of co-contaminants.

7.3 COST ANALYSIS

A cost analysis of a cometabolic biosparging system and two traditional cVOC groundwater treatment approaches to treat a full-scale large, dilute CVOC plume was performed. Cost estimates for full-scale application were developed for the following technologies:

4. Cometabolic biosparging barrier;
5. Passive trench ZVI PRB; and
6. Pump and treat (P&T).

These three technologies were selected for comparison because they are all typically applied as treatment barriers or for cVOC plume capture. The base case presented in Krug et al. (2009) is used as a template for the cost analysis of the above technologies/approaches. The base case presents a situation where a shallow aquifer, consisting of homogeneous silty sands, is contaminated with TCE. The contaminated groundwater extends from 10 to 50 ft bgs, along the direction of groundwater flow for 800 ft, and is 400 ft in width (**Figure 7.1**). The specific base case site characteristics, including aquifer characteristics and design parameters for each of the remedial approaches analyzed, are summarized in **Table 7.2**. The costing for the template site assumes that the source zone has been treated and that there is no continuing source of groundwater contamination. The cost analyses comparing the above approaches are presented below based on a 30-year operating scenario.

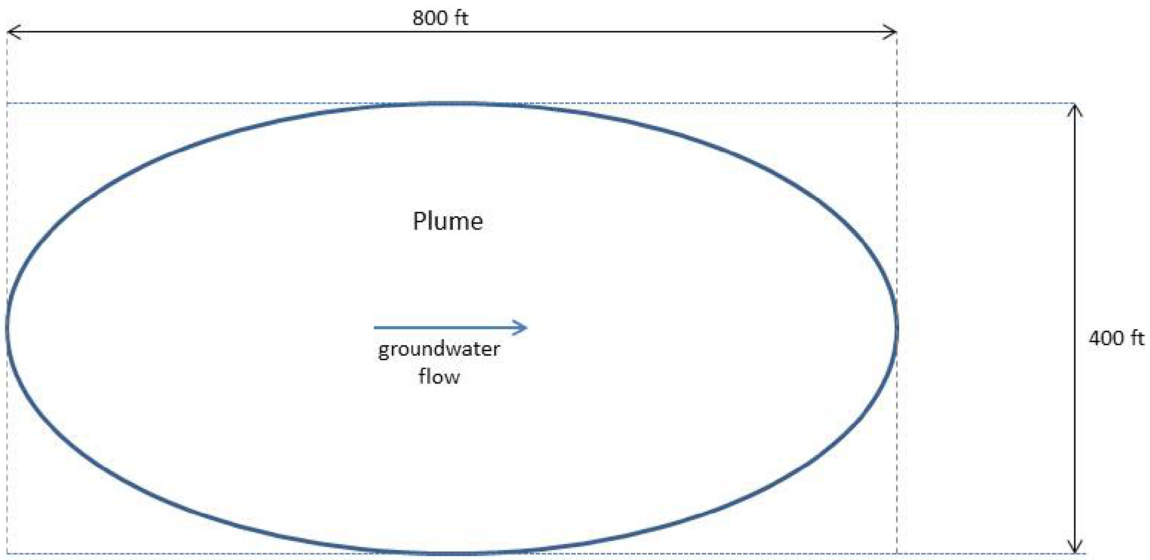

Figure 7.1 Base Case Plume Characteristics

Table 7.2. Summary of Base Case Site Characteristics and Design Parameters

Design Parameter	Units	Alternative		
		Cometabolic Biosparging Barrier	ZVI PRB	Pump and Treat
Width of Plume	feet	400	400	400
Length of Plume	feet	800	800	800
Depth to Water	feet	10	10	10
Vertical Saturated Thickness	feet	40	40	40
Porosity	dimensionless	0.25	0.25	0.25
Gradient	dimensionless	0.008	0.008	0.008
Hydraulic Conductivity	ft/day	2.8	2.8	2.8
Groundwater Seepage Velocity	ft/year	33	33	33
Nitrate Concentration	mg/L	15	15	15
Dissolved Oxygen Concentration	mg/L	5	5	5
Number of Barriers	each	1	1	1
Number of Monitoring Wells	each	10	10	10
Number of Biosparge Wells	each	44	0	0
Number of Extraction/Injection Wells	each	0	0	9

The following subsections provide cost estimates for implementation of each of the three treatment approaches for the base case. The cost estimates provide insight into the comparative capital, O&M, and long-term monitoring (LTM) costs to better identify cost drivers for each technology/approach. Total costs and the Net Present Value (NPV) of future costs were calculated for each of the treatment approaches. Future costs (O&M and LTM costs) are discounted using a -0.3% real discount rate to determine the NPV estimates of these costs (OMB Circular A-94, 2020).

Specifically excluded from consideration are the costs of pre-remedial investigations and treatability studies, assuming the costs for these activities would be similar for each alternative. The cost estimates for each of the alternatives also assume the long-term performance monitoring costs are identical for each alternative. Monitoring is assumed to be at a quarterly frequency for the first five years and an annual frequency thereafter.

7.3.1 Cometabolic Biosparging Barrier

The cometabolic biosparging barrier alternative assumes that a row of biosparge wells will be installed at the downgradient edge and perpendicular to the axis of the plume (**Figure 7.2**). The system will include 22 biosparge well pairs (one shallow and one deep well at each location to sufficiently treat the entire 40 ft plume depth) installed with 20-ft spacing across the 400-ft-wide plume. The biosparge wells would be installed by direct-push drilling methods and consist of one-inch diameter PVC well materials. The system will be powered by solar only (off-the-grid).

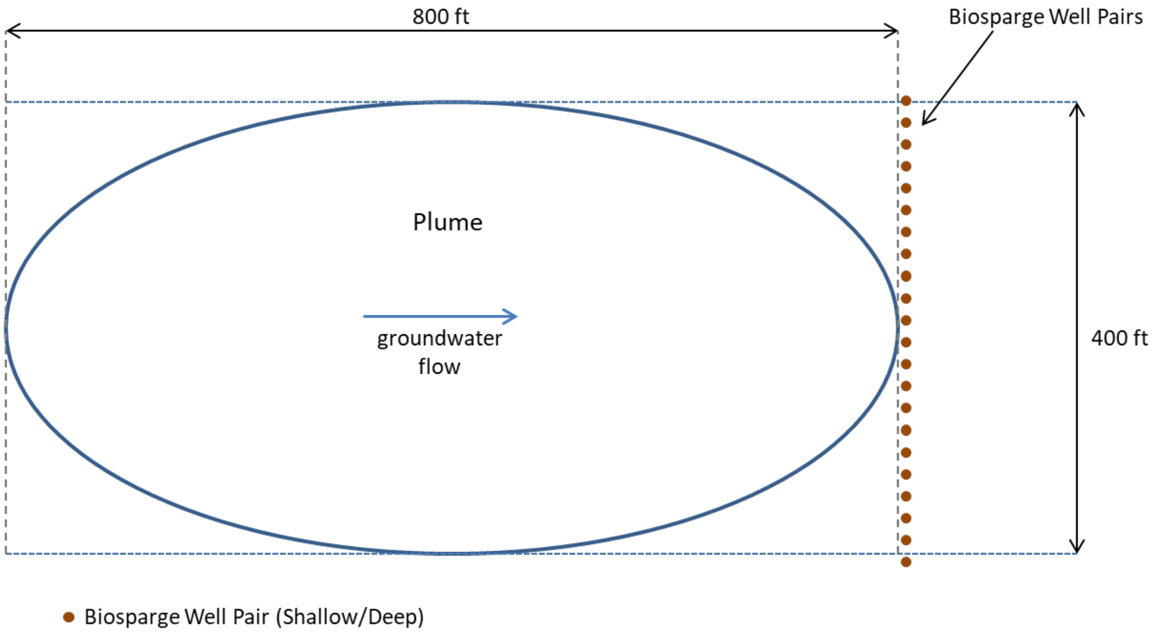

Figure 7.2 Cometabolic Biosparge Barrier Alternative for Plume Cutoff

As summarized in **Table 7.3**, the estimated total costs for the cometabolic biosparge barrier alternative over 30 years are $3,489,500 with a total NPV of lifetime costs of $3,616,221. The capital cost including design, work plan, installation of biosparge and monitoring wells, installation of the solar power system, and fabrication, installation, and start-up of the biosparge system is $445,400. The NPV of the O&M is $2,177,640 for the 30 years of treatment. The O&M costs primarily include the labor and material costs associated with weekly inspections and battery replacement every five years. The costs for materials and other consumables are negligible with this alternative. The NPV of the 30 years of monitoring and reporting costs is $993,181.

Table 7.3. Cost Components for Cometabolic Biosparge Barrier

	Year Cost is Incurred							NPV of Costs*	Total Costs
	1	2	3	4	5	6	6 to 30		
CAPITAL COSTS									
System Design	70,000	-	-	-	-	-		70,000	70,000
Well Installation	130,500	-	-	-	-	-		130,500	130,500
System Installation	224,900	-	-	-	-	-		224,900	224,900
Start-up and Testing	20,000	-	-	-	-	-		20,000	20,000
SUBCOST ($)	445,400	-	-	-	-	-		**445,400**	**445,400**
OPERATION AND MAINTENANCE COSTS									
System Operation and Maintenance	67,670	68,670	68,670	68,670	73,670	68,670	32,227 every year	2,177,640	2,084,100
SUBCOST ($)	**67,670**	**68,670**	**68,670**	**68,670**	**73,670**	**68,670**		**2,177,640**	**2,084,100**
LONG TERM MONITORING COSTS									
Sampling/Analysis/Reporting (Quarterly through 5 years then Annually)	74,500	74,500	74,500	74,500	74,500	23,500	23,500 every year	993,181	960,000
SUBCOST ($)	**74,500**	**74,500**	**74,500**	**74,500**	**74,500**	**23,500**		**993,181**	**960,000**
TOTAL COST ($)	**587,570**	**143,170**	**143,170**	**143,170**	**148,170**	**92,170**		**3,616,221**	**3,489,500**

Notes:

NPV - Net Present Value

* - NPV calculated based on a -0.3% discount rate

This alternative ranks lowest in estimated total remedy cost and lowest in NPV of lifetime costs (see **Table 7.6**). The estimated capital cost for this approach is the lowest of the three alternatives because of the limited infrastructure required and the relative ease of installation. The estimated long-term O&M costs are also the lowest of the three alternatives, which helps make this the least expensive of the alternatives. As with the other alternatives, total remedy costs will increase if the treatment needs to extend beyond 30 years.

7.3.2 Passive Trench ZVI PRB

The passive trench ZVI PRB alternative assumes an initial installation of a ZVI PRB in a trench at the downgradient edge and perpendicular to the axis of the plume (**Figure 7.3**). The PRB will consist of 25% ZVI filings and 75% coarse sand fill mixture (v/v). The PRB will be installed using the one-pass trenching/installation method, and will be 400 ft long, 2 ft wide, and extend down to 50 ft bgs. Pricing for this alternative assumes the PRB will need to be replaced every 10 years due to decline in ZVI reactivity or plugging. The PRB will be maintained for a period of 30 years, with replacements occurring in years 10 and 20. This alternative also assumes 30 years of associated O&M and LTM costs.

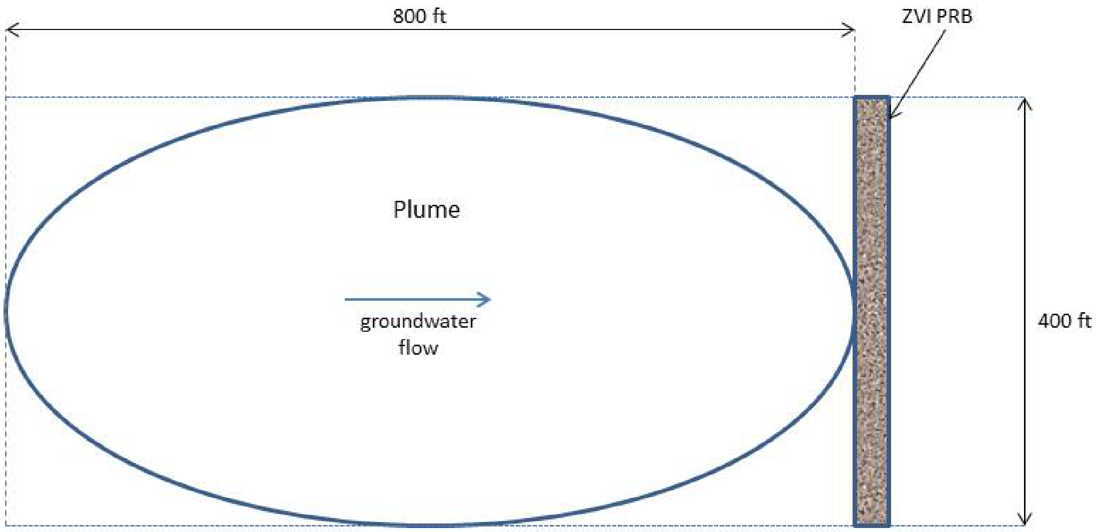

Figure 7.3 Passive PRB Alternative Utilizing ZVI for Plume Cutoff

As summarized in **Table 7.4**, the total costs for this alternative over 30 years are $5,871,375 with a total NPV of lifetime costs of $6,037,074. The capital cost including design, work plan, ZVI PRB installation, and installation of monitoring wells is $1,717,375. The NPV of the O&M is $3,326,519, which is the NPV associated with the replacement of the PRB every 10 years. The NPV of the 30 years of monitoring and reporting costs is $993,181.

Table 7.4. Cost Components for ZVI PRB

	Year Cost is Incurred								NPV of Costs*	Total Costs
	1	2 to 5	6	7	8	9	10	11 to 30		
CAPITAL COSTS										
System Design	70,000		-	-	-	-	-		70,000	70,000
Well Installation	50,375		-	-	-	-	-		50,375	50,375
Trench Installation	1,597,000		-	-	-	-	-		1,597,000	1,597,000
Start-up and Testing**	-		-	-	-	-	-		0	0
SUBCOST ($)	1,717,375		-	-	-	-	-		**1,717,375**	**1,717,375**
OPERATION AND MAINTENANCE COSTS										
ZVI Replacement Cost	-		-	-	-	-	1,597,000	1,457,000 year 20	3,326,519	3,194,000
SUBCOST ($)	**-**		**-**	**-**	**-**	**-**	**1,597,000**		**3,326,519**	**3,194,000**
LONG TERM MONITORING COSTS										
Sampling/Analysis/Reporting	74,500	74,500 years 2 to 5	23,500	23,500	23,500	23,500	23,500	23,500 every year	993,181	960,000
(Quarterly through 5 years then Annually)										
SUBCOST ($)	74,500		23,500	23,500	23,500	23,500	23,500		**993,181**	**960,000**
TOTAL COST ($)	**1,791,875**		**23,500**	**23,500**	**23,500**	**23,500**	**1,620,500**		**6,037,074**	**5,871,375**

Notes:

NPV - Net Present Value

* - NPV calculated based on a -0.3% discount rate

** - No "Start-up and Testing" costs are included because no operating equipment is left behind following PRB installation

This alternative ranks second in estimated total remedy cost and NPV of lifetime costs (**Table 7.6**). The estimated capital costs for this approach are the second lowest, due largely to the relatively high cost of the initial PRB installation. The long-term O&M costs associated with this alternative are also the second lowest due to the lack of O&M requirements between PRB replacements. The total remedy costs for this alternative would increase significantly if the PRB lifespan was less than 10 years or if treatment extended beyond 30 years.

7.3.3 Active Pump and Treat (P&T)

The groundwater P&T system alternative is similar to the other technologies in that a downgradient barrier is installed (**Figure 7.4**). The system includes a row of four extraction wells (EWs) and five injection wells (IWs), which would be used to create a groundwater capture zone at the downgradient edge perpendicular to the axis of the plume (**Figure 7.4**). The extracted groundwater would be treated above-ground by air stripping followed by treatment with granular activated carbon (GAC). The treated groundwater would be re-injected providing hydraulic control and mass removal at the downgradient edge of the plume. The P&T system would be maintained for a period of 30 years. This alternative also assumes 30 years of associated O&M and LTM costs.

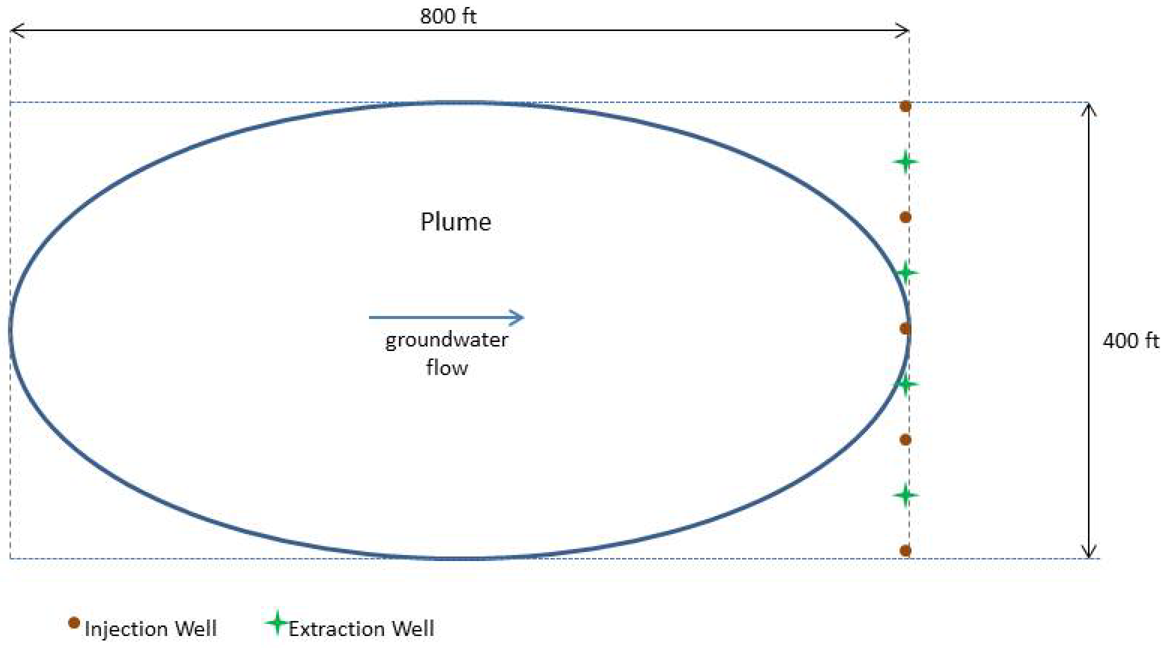

Figure 7.4 P&T Alternative for Plume Cutoff

As summarized in **Table 7.5**, the total cost for this alternative over 30 years is $7,658,029 with a total NPV of lifetime costs of $7,906,330. The capital cost including design, work plan, installation of IW/EW and monitoring wells, construction of the groundwater treatment system, and system start up and testing is $1,911,013. The NPV of the O&M is $5,002,137. The O&M costs include the labor costs associated with system O&M, costs for equipment repair and replacement, electrical costs, and cost for the replacement and disposal of the GAC. The NPV of the 30 years of monitoring and reporting costs is $993,181.

Table 7.5. Cost Components for P&T

	Year Cost is Incurred							NPV of Costs*	Total Costs
	1	2	3	4	5	6	6 to 30		
CAPITAL COSTS									
System Design	99,387	-	-	-	-	-		99,387	99,387
Well Installation	141,185	-	-	-	-	-		141,185	141,185
System Installation	1,641,566	-	-	-	-	-		1,641,566	1,641,566
Start-up and Testing	28,875	-	-	-	-	-		28,875	28,875
SUBCOST ($)	1,911,013	-	-	-	-	-		**1,911,013**	**1,911,013**
OPERATION AND MAINTENANCE COSTS									
System Operation and Maintenance	153,719	159,769	159,769	159,769	159,769	159,769	145,244 every year	5,002,137	4,787,017
SUBCOST ($)	**153,719**	**159,769**	**159,769**	**159,769**	**159,769**	**159,769**		**5,002,137**	**4,787,017**
LONG TERM MONITORING COSTS									
Sampling/Analysis/Reporting	74,500	74,500	74,500	74,500	74,500	23,500	23,500 every year	993,181	960,000
(Quarterly through 5 years then Annually)									
SUBCOST ($)	**74,500**	**74,500**	**74,500**	**74,500**	**74,500**	**23,500**		**993,181**	**960,000**
TOTAL COST ($)	**2,139,231**	**234,269**	**234,269**	**234,269**	**234,269**	**183,269**		**7,906,330**	**7,658,029**

Notes:
NPV - Net Present Value
* - NPV calculated based on a -0.3% discount rate

This alternative ranks highest in both estimated total remedy cost and NPV of lifetime costs (**Table 7.6**). The estimated capital costs for this alternative are higher than the other two alternatives because of the higher costs associated with constructing a groundwater treatment system. The high O&M costs associated with operating the P&T system are what makes this alternative the most expensive of the alternatives. As with the other approaches, total remedy costs will increase if the treatment needs to extend beyond 30 years.

Table 7.6. Summary of Costs for Treatment Alternatives.

Alternative	Capital Costs	NPV of 30 Years of O&M Costs	NPV of 30 Years of Monitoring Costs	NPV of 30 Years of Total Remedy Costs	Total 30-Year Remedy Costs
Cometabolic Biosparging Barrier	$445	$2,178	$993	$3,616	$3,490
ZVI PRB	$1,717	$3,327	$993	$6,037	$5,871
Pump and Treat	$1,911	$5,002	$993	$7,906	$7,658

Notes:
All costs are in thousands of dollars
NPV - Net Present Value; current value of future costs based on a -0.3% annual discount rate
O&M - Operation and Maintenance

8.0 IMPLEMENTATION ISSUES

The primary end-users of this technology are expected to be DoD and commercial site managers, and their contractors, consultants, and engineers. The general concerns of these end users are likely to include the following: (1) technology applicability and performance under local site conditions; (2) safety; (3) secondary groundwater impacts, and (4) technology cost compared to other remedial options. These implementation issues are addressed in the following subsections.

8.1 TECHNOLOGY APPLICABILITY AND PERFORMANCE UNDER LOCAL SITE CONDITIONS

The primary objective of cometabolic treatment for large, dilute cVOC plumes is to supply a gaseous co-substrate (i.e., alkane or alkene gas) and oxygen to an aquifer for microbial growth. There are number of different approaches to achieve this end whose applicability depends on site geology/hydrogeology and plume characteristics. These approaches include including (1) oxygen/air- and propane-biosparging as applied in this demonstration, (2) groundwater recirculation with above-ground co-substrate gas and oxygen addition, (3) bubble-free gas injection systems, and (4) trenches with air and propane injection lines, among others (Steffan et al., 2003). The critical objective with any of these approaches is to evenly and consistently distribute the co-substrate and oxygen gas throughout the desired treatment area.

During ESTCP project ER-200828 (*Field Demonstration of Propane Biosparging for In Situ Remediation of N-Nitrosodimethylamine (NDMA) in Groundwater*) we performed biosparging by injecting propane gas into a groundwater aquifer in a stream of air. Data from that ESTCP field test clearly indicate that propane biosparging was an effective approach to reduce the concentrations of NDMA in a groundwater aquifer by 3 to 4 orders of magnitude, and that concentrations in the low ng/L range can be achieved with continuous treatment. These results are consistent with data achieved in pure culture studies as well as with various bioreactor tests.

We recently tested a groundwater recirculation design for treatment of EDB in groundwater using ethane gas and pure oxygen (Hatzinger et al., 2015, Hatzinger and Begley, 2014). In this case, groundwater was pumped from an existing extraction well at 10-12 gallons per minute, amended with oxygen, ethane gas, and inorganic nutrients, and then re-injected into an injection well (approximately 60 ft upgradient), forming a closed loop. Good gas distribution was observed in system monitoring wells and the biodegradation of ethane and EDB were documented throughout the demonstration plot. EDB reached concentrations below the stringent Massachusetts MCL of 0.02 µg/L. The one potential O&M issue with this approach was the observation of biofouling in the injection well tubing when ethane concentrations were increased from 2 mg/L in the injected water to 4 mg/L during one phase of the study.

A recent study also examined the use of bubble-free gas injection systems to supply oxygen and propane to a groundwater aquifer (Shaw Environmental, 2013). This approach was significantly less successful than either biosparging or groundwater recirculation for two main reasons (1) the inability to adequately control the oxygen:propane ratio with the system used and (2) the inability to supply and distribute enough oxygen in the aquifer to overcome the highly reducing geochemical conditions. Gas distribution can be a significant limitation with this type of system.

The biosparging technology utilized during this demonstration consisted of the injection of propane and ammonia gases (mixed with nitrogen) and pure oxygen into a groundwater aquifer. This approach is both highly flexible and widely applicable under differing aquifer conditions. In this case, biosparging was conducted in an unconfined, layered water table aquifer. One of the significant advantages of this approach is that groundwater does not have to be pumped from the subsurface, thus avoiding the common capital costs and O&M issues with groundwater extraction and reinjection. This approach can also be used cost-effectively in deep as well as shallow aquifers and to aerially wide plumes. Aquifer depth is one of the limiting factors for fully passive designs, which become increasingly expensive due to close spacing of injection points and/or technically impractical (e.g., for passive trench barriers) as the depth to the water table increases (Stroo and Ward, 2009). A semi-passive pumping design has fewer limitations with depth. Similarly, wide plumes are more readily treated with active or semi-passive approaches than with fully passive designs, as a few wells (and high sparging rates) can often be used to distribute co-substrate over a large area rather than closely spaced wells or injection points [see Stroo and Ward (2009) for further comparisons of different amendment designs].

8.2 SAFETY

Because propane and other alkane/alkene gases are flammable, specific safety measures must be considered when designing, installing, and monitoring an *in situ* cometabolic biosparging system. However, it is very easy for a competent engineer to design a system that is safe for operation. All electrical equipment and wiring in the system enclosure supplying propane should be intrinsically safe, and the propane cylinders/tanks should be stored outside of the trailer. During this demonstration, we stored compressed oxygen and nitrogen on one side of the enclosure, and propane and ammonia on the other side of the enclosure. The biosparging system components were housed within a 20-ft long Conex box. The box had a partition wall separating the enclosure into two spaces. The smaller of the two spaces was the system control room, which was rated as a non-hazardous atmosphere, and housed the PLC/SCADA system with integrated computer, electrical control panel, solar power distribution systems, and a combination air conditioner/heater. The larger space, which included gas piping/fittings, mass flow controllers, well control solenoid valves and other system process components, was rated as a Class 1, Division 2 atmosphere, due to the presence of flammable sparge gases flowing through the piping in this portion of the enclosure. All electrical components and connections in this portion of the enclosure were intrinsically safe to meet the hazardous atmosphere classification. This space was monitored with three separate gas detectors, which continuously measured oxygen, propane, and ammonia levels within the enclosure, and had the ability to shut-down the system and notify appropriate personnel in the case of an alarm condition.

8.3 SECONDARY GROUNDWATER IMPACTS

One of the significant advantages of an aerobic treatment system of this type is that there are typically very few negative impacts to groundwater geochemistry, particularly in comparison to in situ anaerobic systems where large amounts of carbon substrate are applied to treat contaminants. As noted in **Sections 5.7.4** and **6.2**, DO throughout the biobarrier typically increased from < 1 mg/L to > 3 mg/L over the course of this demonstration. Similarly, the ORP in the biobarrier was near or greater than +50 mV, and the pH generally remained between 6.5 and 7. Thus, the water became aerobic and oxidizing and remained neutral in pH. Furthermore, based on data collected during the post treatment sampling event (as discussed in **Section 5.7**), the aquifer geochemistry returned to baseline conditions within 105 days of shutting down the biosparging system.

8.4 TECHNOLOGY COSTS

The expected cost drivers for the installation and operation of an in situ biosparging system for cVOCs and comparisons to other remedial approaches are provided in **Section 7.0**.

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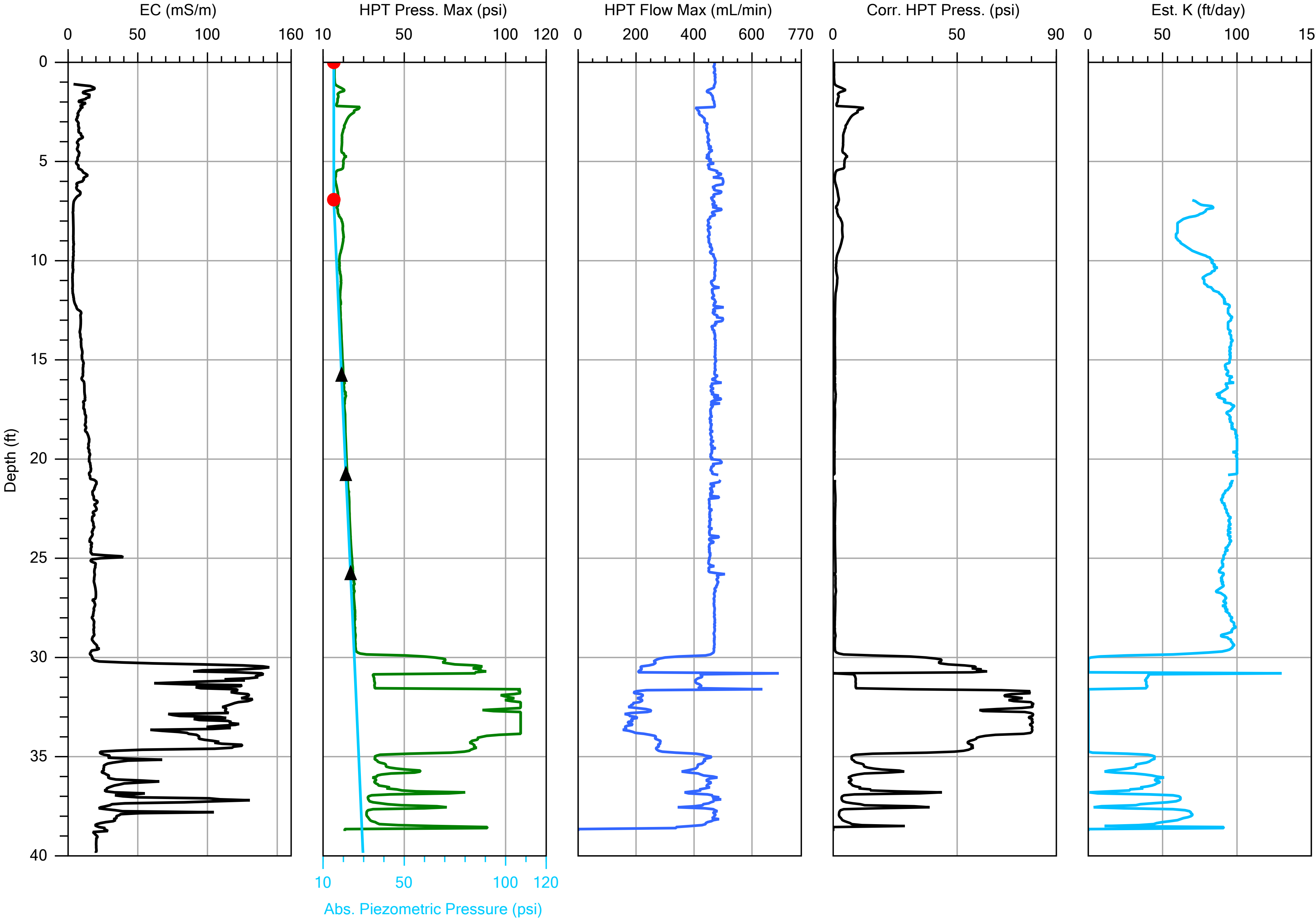
APPENDIX A POINTS OF CONTACT

POINT OF CONTACT Name	ORGANIZATION Name Address	CONTACT INFORMATION Phone E-mail	ROLE IN PROJECT
David R. Lippincott, PG	APTIM Federal Services 17 Princess Road Lawrenceville, NJ 08648	609-895-5380 direct 609-605-0883 cell david.lippincott@aptim.com	Principal Investigator
Paul B. Hatzinger, PhD	APTIM Federal Services 17 Princess Road Lawrenceville, NJ 08648	609-895-5356 direct 267-337-4003 cell paul.hatzinger@aptim.com	Co-Principal Investigator
Graig M. Lavorgna	APTIM Federal Services 17 Princess Road Lawrenceville, NJ 08648	609-895-5343 direct 908-309-7651 cell graig.lavorgna@aptim.com	Project Engineer Field Task Manager
James Begley	MT Environmental Restoration 147 Elm Street Duxbury, MA 02332	508-732-0121 direct 508-360-2859 cell jbegley@mtenvironmental.com	Technical/Engineering Support
Andrea Leeson, PhD	SERDP/ESTCP 4800 Mark Center Drive Suite 17D03 Alexandria, VA 22350-3605	703-696-2118 direct 703-696-2114 fax andrea.leeson@gmail.com	ESTCP Environmental Restoration Program Manager
Catherine Jerrard, PE, PMP	AFCEC/CIBW 706 Hangar Road Rome, New York 13441	315-356-0810 direct 315-723-4509 cell catherine.jerrard@us.af.mil	AFCEC-BRAC Environmental Coordinator
Meredith Amick, PE	Bureau of Land and Waste Management South Carolina Dept. of Health & Environmental Control	803-898-0368 direct amickms@dhec.sc.gov	SCDHEC Environmental Engineer RCRA Federal Facilities Section
Ryan Betcher, AAE	Horry County Dept of Airports 1100 Jetport Road Myrtle Beach, SC 29577	843-839-7368 direct 843-685-3221 cell betcherr@HorryCounty.org	Myrtle Beach Int’l Airport Director of Special Projects

APPENDIX B HPT, SOIL BORING, AND WELL INSTALLATION LOGS



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DRILLING | TECHNICAL SERVICES
EXCELLENCE ON EVERY LEVEL™

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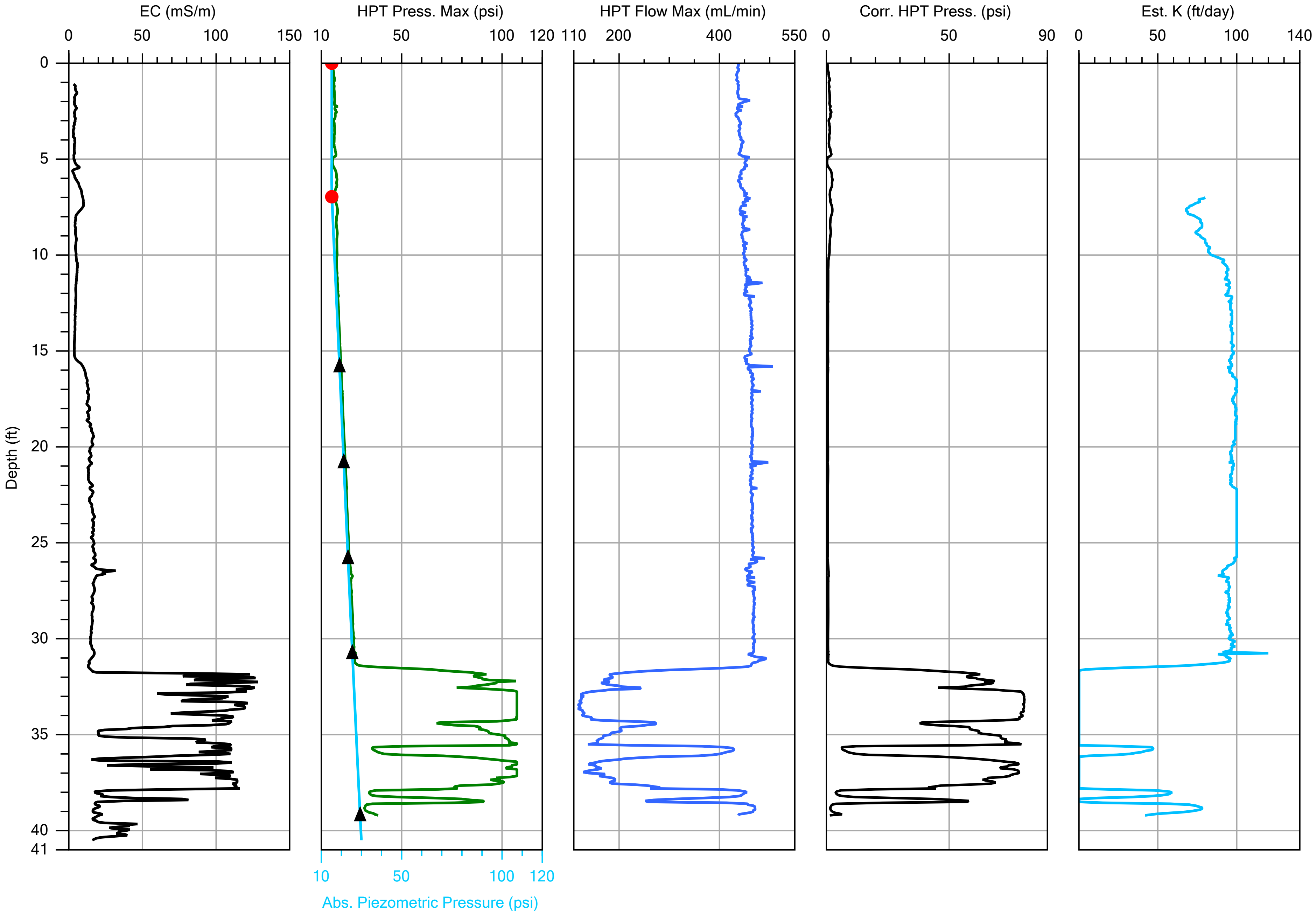

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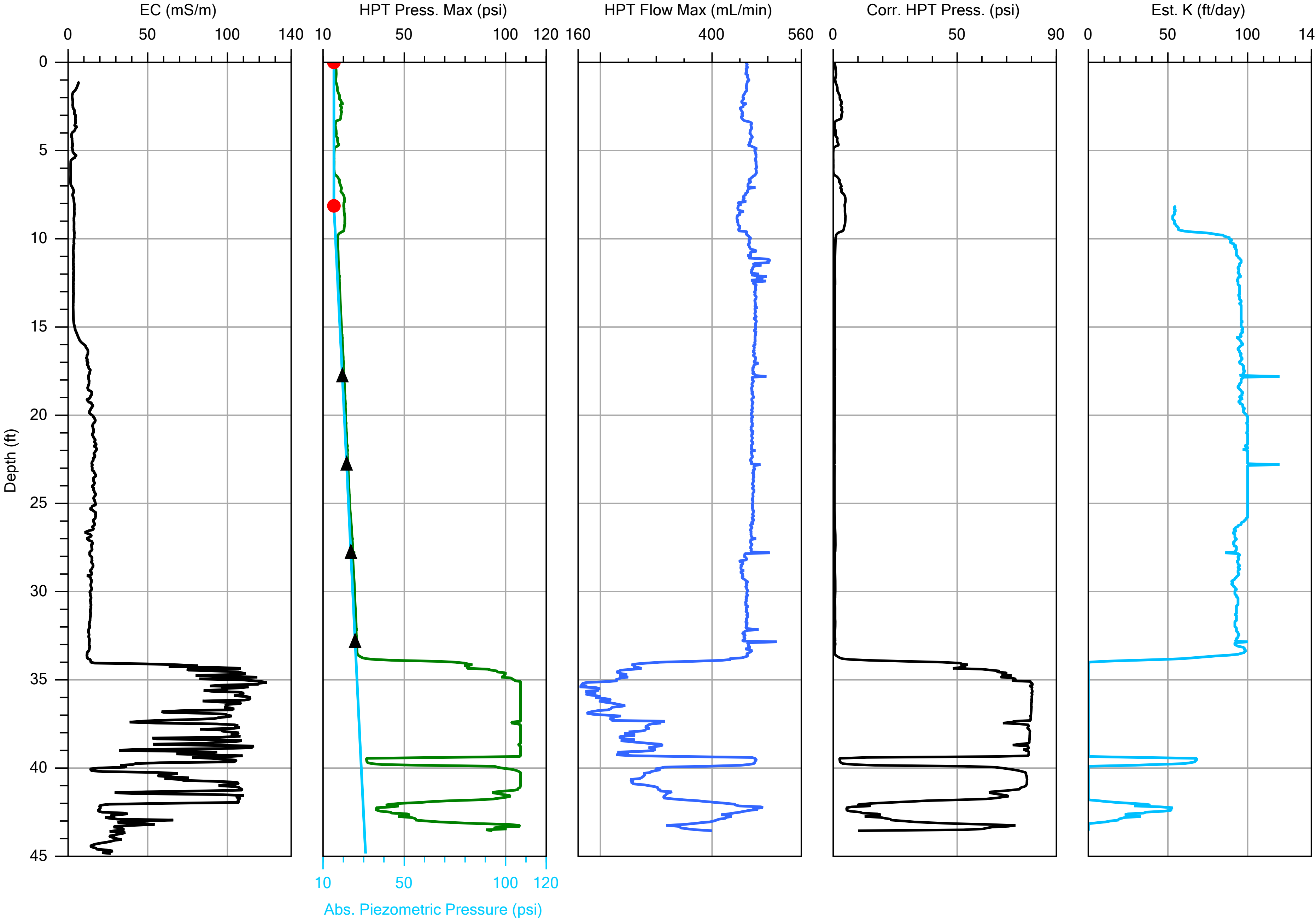

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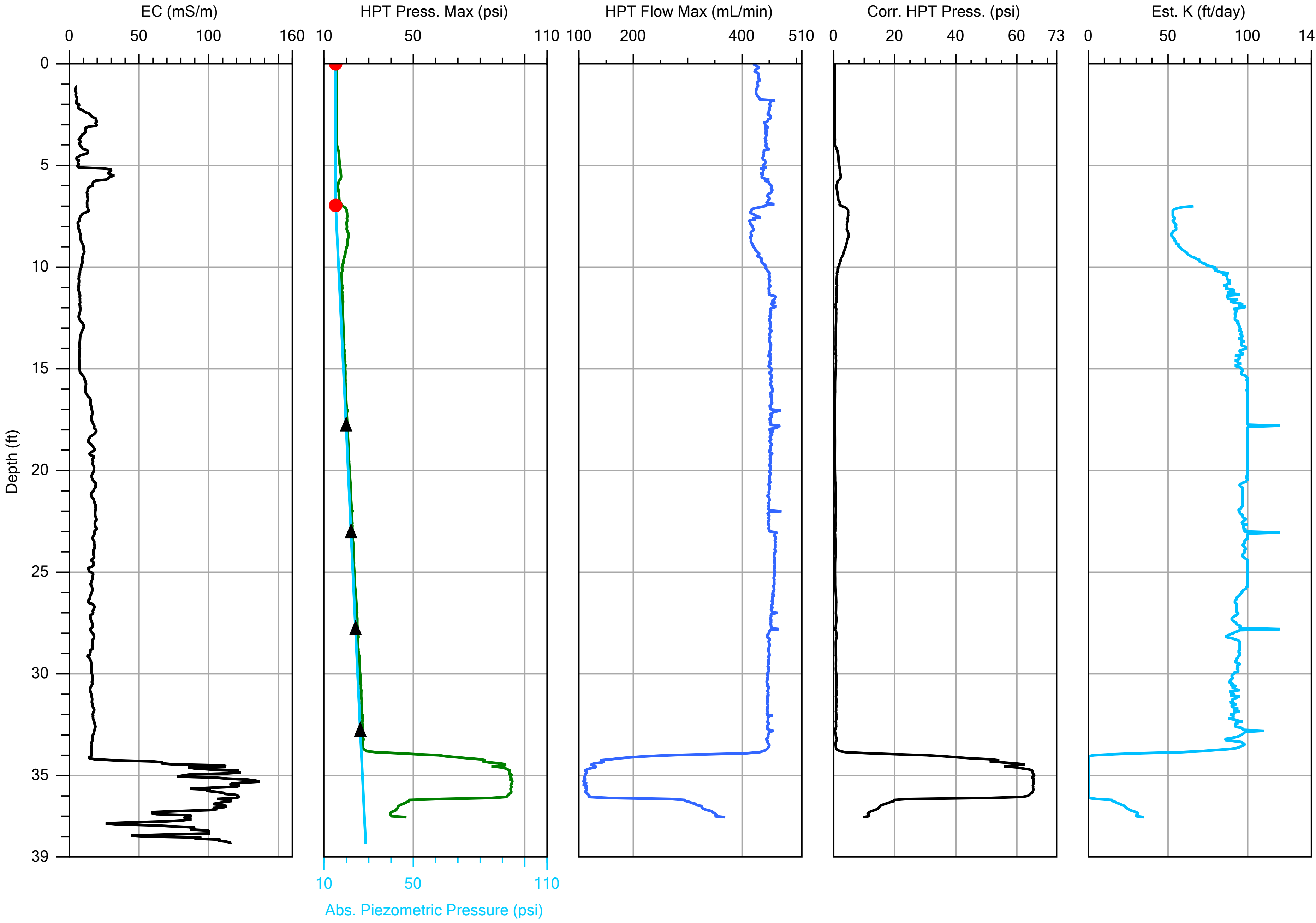

CASCADE
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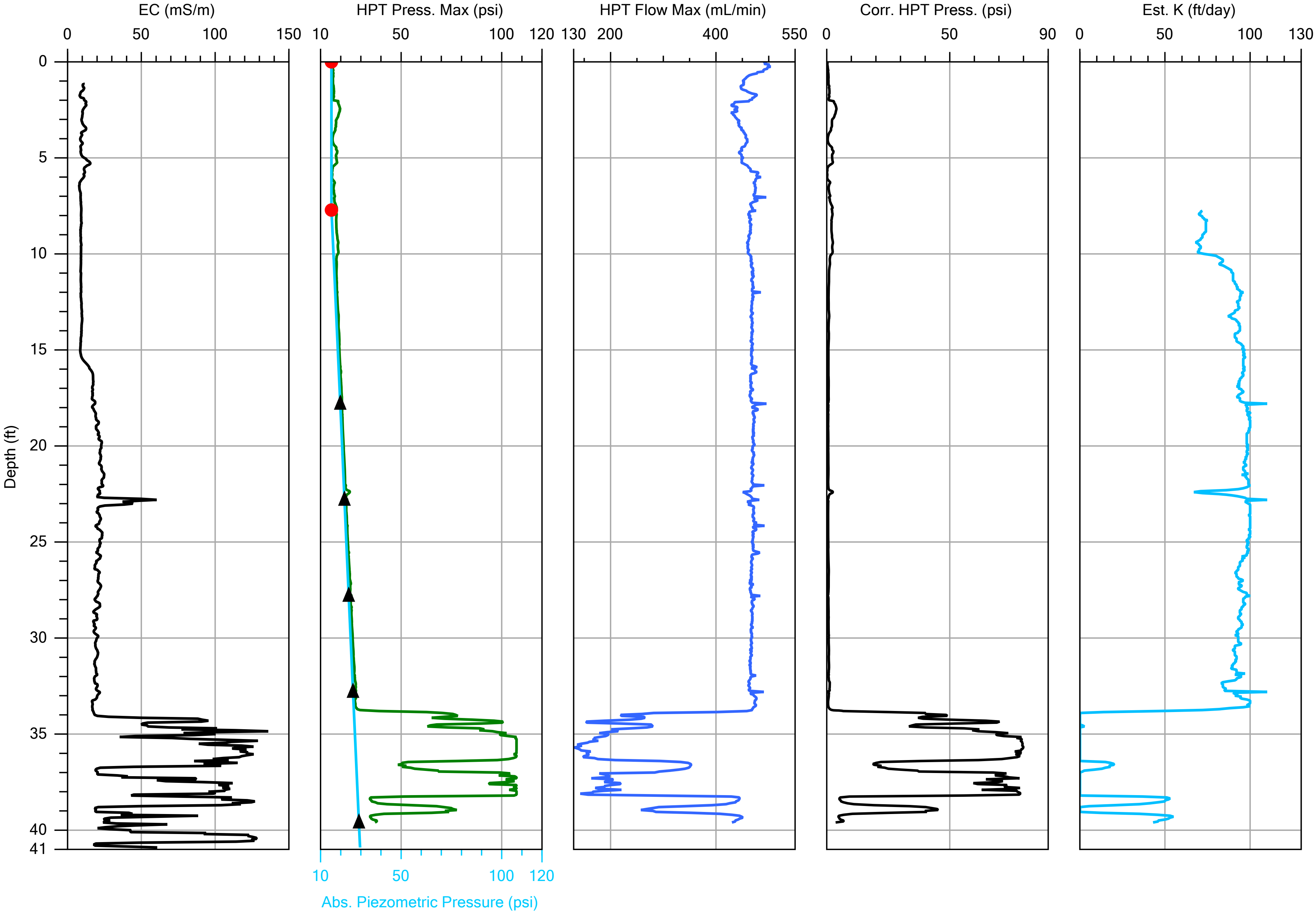

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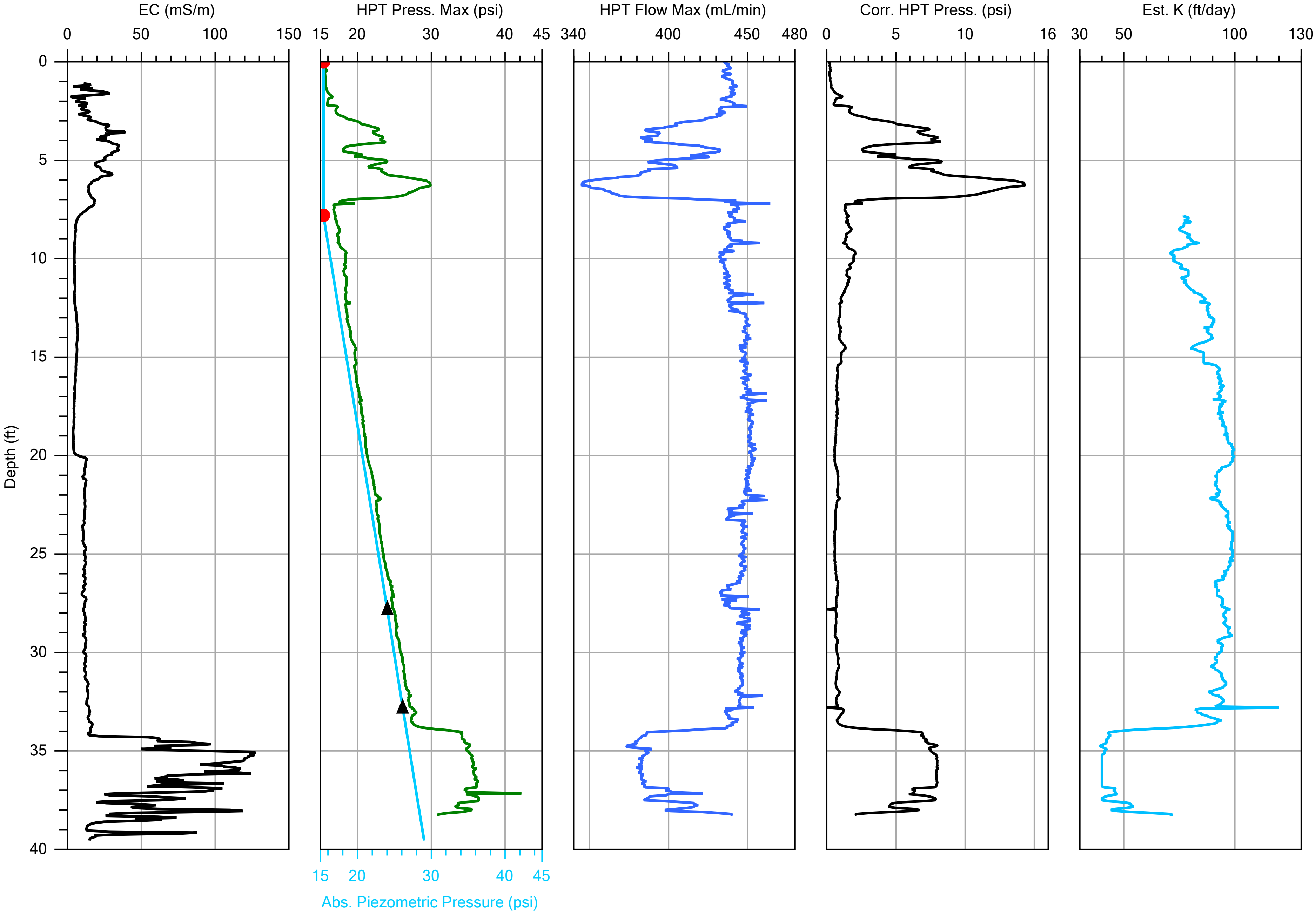

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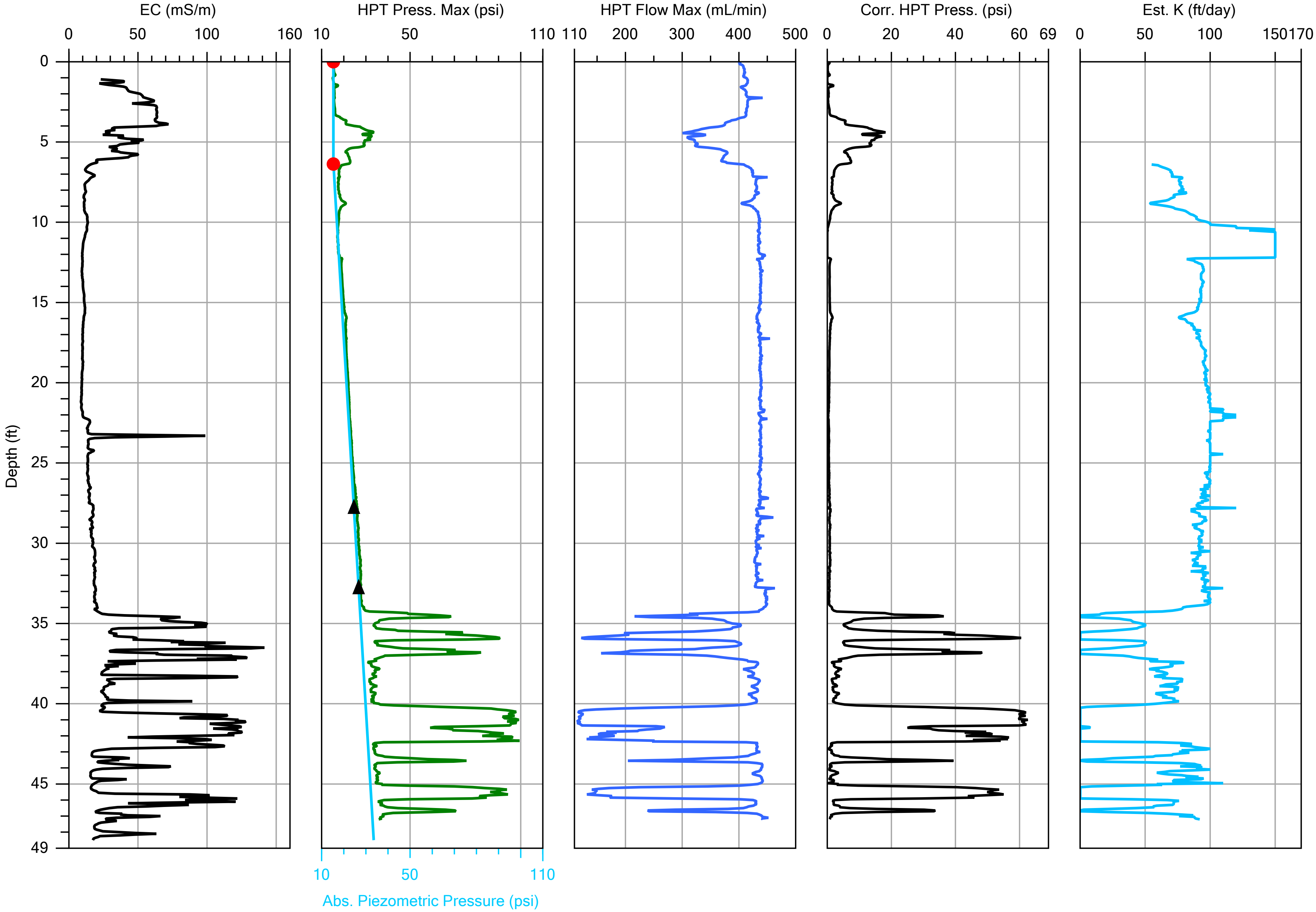

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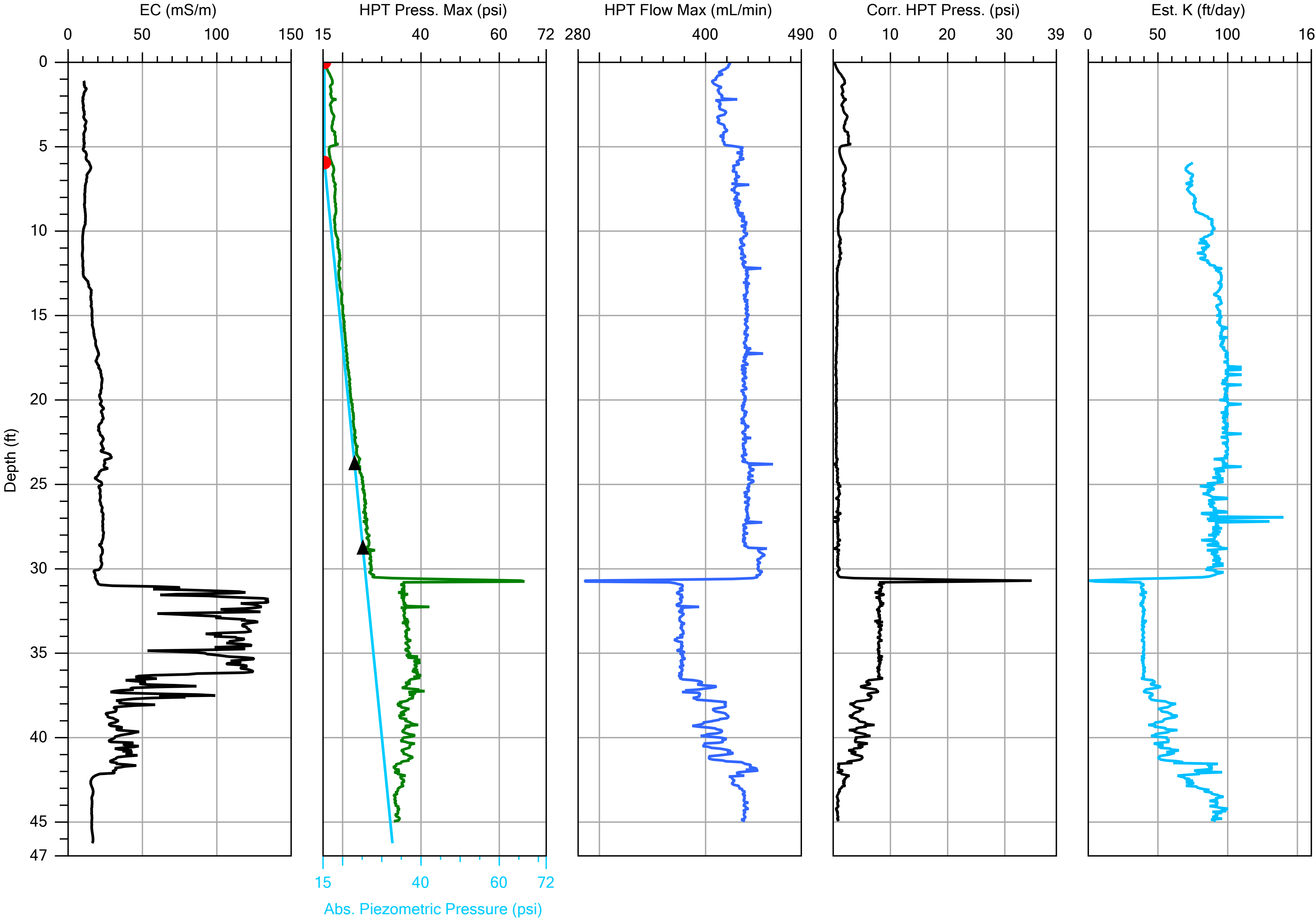

Company: CASCADE	Operator: Mark Candelario	File: HPT-11.MHP
		Date: 8/30/2017
Project ID: 204.17.1088	Client: APTIM	Location:

APTIM
17 Princess Road
Lawrenceville, NJ 08648

BORING NUMBER ESTCP-B01

CLIENT	ESTCP	**PROJECT NAME**	Large Plume
PROJECT NUMBER	500814	**PROJECT LOCATION**	Myrtle Beach, SC
DATE STARTED	8/22/17 **COMPLETED** 8/22/17	**GROUND ELEVATION**	100 ft **HOLE SIZE** 2 inches
DRILLING CONTRACTOR	Cascade	**GROUND WATER LEVELS:**	
DRILLING METHOD	Geoprobe	**AT TIME OF DRILLING**	--- 7.7 to 10.0 feet
LOGGED BY	M Tucker **CHECKED BY** D Lippincott	**AT END OF DRILLING**	---
NOTES		**AFTER DRILLING**	---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	PID (ppm)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0	1	100	0	SP	2.0	(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	98.0
5				SP	6.2	(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	93.8
	2	53	0	SP	7.7	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	92.3
10					10.0	NO RECOVERY.	90.0
	3	52	0	SP	10.9	(SP) Medium gray medium SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	89.1
				SP	12.6	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	87.4
15					15.0	NO RECOVERY.	85.0
	4	90	0	SP	17.7	(SP) Light gray fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	82.3
				SW	19.5	(SW) Light gray (speckled white and gray), well-graded SAND and shell hash, with gravel-sized shells, stratified.	80.5
20					20.0	NO RECOVERY.	80.0
	5	78	0	SW	23.9	(SW) SAND with shell hash, same as above.	76.1
25					25.0	NO RECOVERY.	75.0
	6	92	0	SW	28.9	(SW) SAND with shell hash, same as above.	71.1
				SP	29.6	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet, no cementation.	70.4
30					30.0	NO RECOVERY.	70.0
	7	90	0	SP	34.5	(SP) Light gray fine SAND, same as above.	65.5
35					35.0	NO RECOVERY.	65.0
				CL		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand.	

(Continued Next Page)

BORING NUMBER ESTCP-B01

CLIENT ESTCP

PROJECT NAME Large Plume

PROJECT NUMBER 500814

PROJECT LOCATION Myrtle Beach, SC

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	PID (ppm)	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION	
	8	93	0	CL	▨	39.7	(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand. *(continued)*	60.3
40						40.0	NO RECOVERY.	60.0
	9	92	0	CL	▨	42.2	(CL) Gray lean CLAY, same as above.	57.8
				SW	░	42.4	(SW) Light gray fine to coarse SAND with shell hash.	57.6
				SP	░	44.6	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet.	55.4
45						45.0	NO RECOVERY	55.0
	10	87	0	SP	░	47.4	(SP) Light gray fine SAND, same as above.	52.6
				CL	░	47.4	(CL) Band of gray clay.	52.6
				SP	░	49.3	(SP) Light gray medium SAND, dense, wet, homogeneous, no cementation.	50.7
50						50.0	NO RECOVERY.	50.0

Bottom of borehole at 50.0 feet.

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17 Princess Road
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BORING NUMBER ESTCP-B02

PAGE 1 OF 2

CLIENT	ESTCP	**PROJECT NAME**	Large Plume
PROJECT NUMBER	500814	**PROJECT LOCATION**	Myrtle Beach, SC
DATE STARTED	8/31/17 **COMPLETED** 9/5/17	**GROUND ELEVATION**	100 ft **HOLE SIZE** 2 inches
DRILLING CONTRACTOR	Cascade	**GROUND WATER LEVELS:**	
DRILLING METHOD	Geoprobe	∇ **AT TIME OF DRILLING**	7.80 ft / Elev 92.20 ft (Approx.)
LOGGED BY	M Tucker **CHECKED BY** D Lippincott	**AT END OF DRILLING**	---
NOTES		**AFTER DRILLING**	---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	PID (ppm)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION		
0	1	100	0	SP	⁘	(SP) Brown fine SAND, loose, wet (top soil).	1.0	99.0
				SC	⁘	(SC) Brown fine SAND, clayey (top soil).	2.0	98.0
5				SC	▨	(SC) Light brown fine SAND, clayey, firm, moist.	5.3	94.7
	2	70	0	SP	⁘	(SP) Brown fine SAND, poorly-graded (well-sorted), wet at 7.8 feet, no cementation. ∇	8.5	91.5
10						NO RECOVERY.	10.0	90.0
	3	60	0	SP	⁘	(SP) Light brownish gray fine SAND, loose, wet.	11.9	88.1
				SP	⁘	(SP) Medium gray medium SAND, loose, wet.	13.0	87.0
15						NO RECOVERY.	15.0	85.0
	4	92	0	SW	⁙	(SW) Medium gray (speckled white and gray) SAND with shell hash, gravel-sized shells to 1 inch, well-graded, wet, stratified.	19.6	80.4
20						NO RECOVERY.	20.0	80.0
	5	90	0	SW	⁙	(SW) SAND with shell hash, same as above.	24.5	75.5
25						NO RECOVERY.	25.0	75.0
	6	92	0	SW	⁙	(SW) SAND with shell hash, same as above.	27.3	72.7
				SP	⁘	(SP) Light gray fine SAND, poorly-graded (very well-sorted), dense, wet, homogeneous.	29.6	70.4
30						NO RECOVERY.	30.0	70.0
	7	100	0	SP	⁘	(SP) Light gray fine SAND, same as above.	34.7	65.3
35				CL	▨	(CL) Greenish gray lean CLAY, moist, firm, moderate plasticity, moderate dry strength, no dilatancy, contains numerous thin (1/8 inch) bands of white fine sand.		

(Continued Next Page)

APTIM
17 Princess Road
Lawrenceville, NJ 08648

BORING NUMBER ESTCP-B02

PAGE 2 OF 2

CLIENT ESTCP

PROJECT NAME Large Plume

PROJECT NUMBER 500814

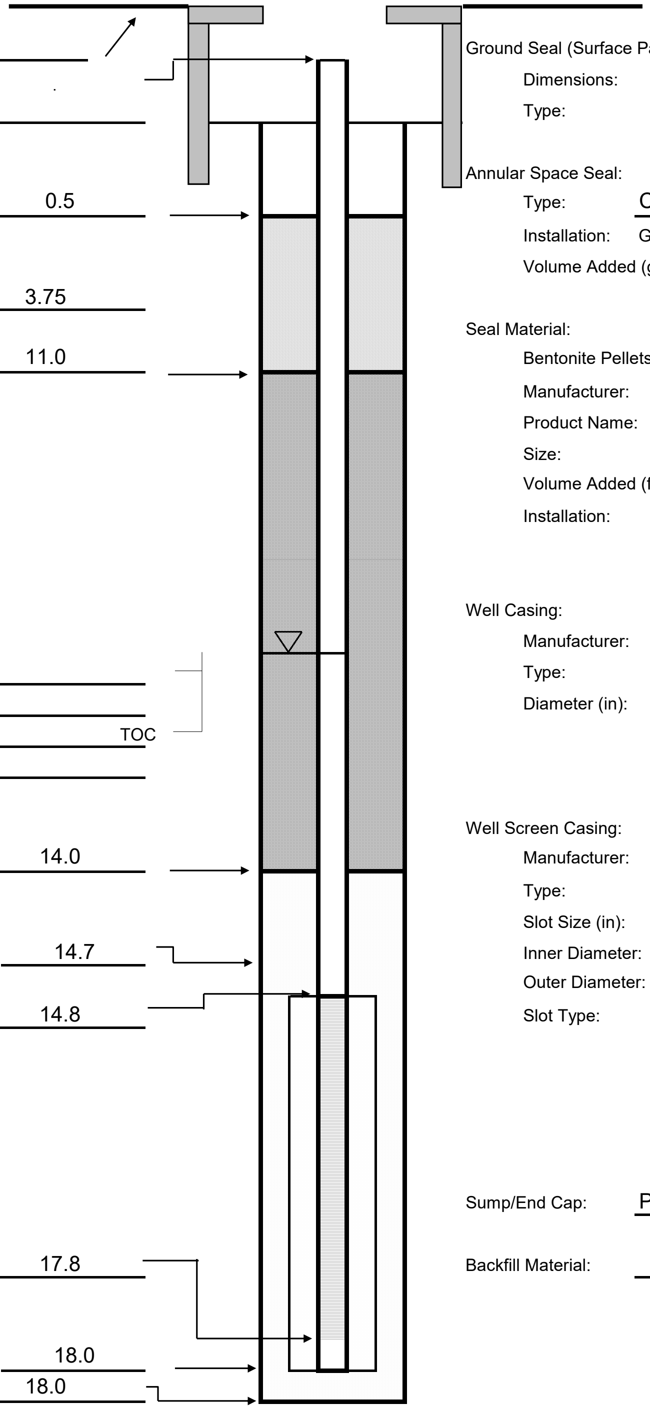
PROJECT LOCATION Myrtle Beach, SC

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	PID (ppm)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
	8	92	0	CL	▨	(CL) Greenish gray lean CLAY, moist, firm, moderate plasticity, moderate dry strength, no dilatancy, contains numerous thin (1/8 inch) bands of white fine sand. *(continued)*
					39.6	60.4
40					40.0	NO RECOVERY. 60.0

Bottom of borehole at 40.0 feet.

Monitoring Well Construction Log

Project:	**Cometabolic Biosparging: Large Dilute Plume**	**Well Number:**	PMW-0-1
Location:	**Former Myrtle Beach Air Force Base - South Carolina**	**Site Location:**	**Bldg 324** OU #
Client:	**ESTCP**	**Installation Date**	**6/2/2019**
Subcontractor:	**APTIM**	**Northing:**	
Driller:	**Cascade - Charles Terry - License B2080**	**Easting:**	
APTIM Field Representative:	**A. R. Tingle**	**Project Number:**	**500814**



Land Surface Elevation (ft msl):

Top of Casing Elevation (ft msl):

Top of Annular Seal (ft bgs): 0.5

Approximate Diameter of Borehole (in): 3.75

Top of Pellet Seal (ft bgs): 11.0

Depth to Water (ft bgs):

During Drilling:

Date:

Post Development:

Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 14.0

Top of Pre-Pack Assembly (ft bgs): 14.7

Top of Screen Interval (ft bgs): 14.8

Bottom of Screen Interval (ft): 17.8

Bottom of Pre-Pack Assembly (ft): 18.0

Bottom of Borehole (ft): 18.0

Ground Seal (Surface Pad)

Dimensions: 18-inch x 18-inch x 4-inch

Type: Concrete

Annular Space Seal:

Type: Cement Bentonite Grout

Installation: Gravity Tremie Pumped

Volume Added (gal):

Seal Material:

Bentonite Pellets

Manufacturer: PDS Co Inc.

Product Name: Pel-Plug TR30

Size: 1/4 inch diameter

Volume Added (ft^3):

Installation: Gravity* Tremie

* throgh the Geoprobe rods

Well Casing:

Manufacturer: Johnson

Type: Schedule 40 PVC

Diameter (in): 1.25 inch

Well Screen Casing:

Manufacturer: Johnson

Type: Prepack

Slot Size (in): 0.010

Inner Diameter: 1.25"

Outer Diameter: 2.8"

Slot Type: Factory slot

Sump/End Cap: PVC - 0.2-foot

Backfill Material:

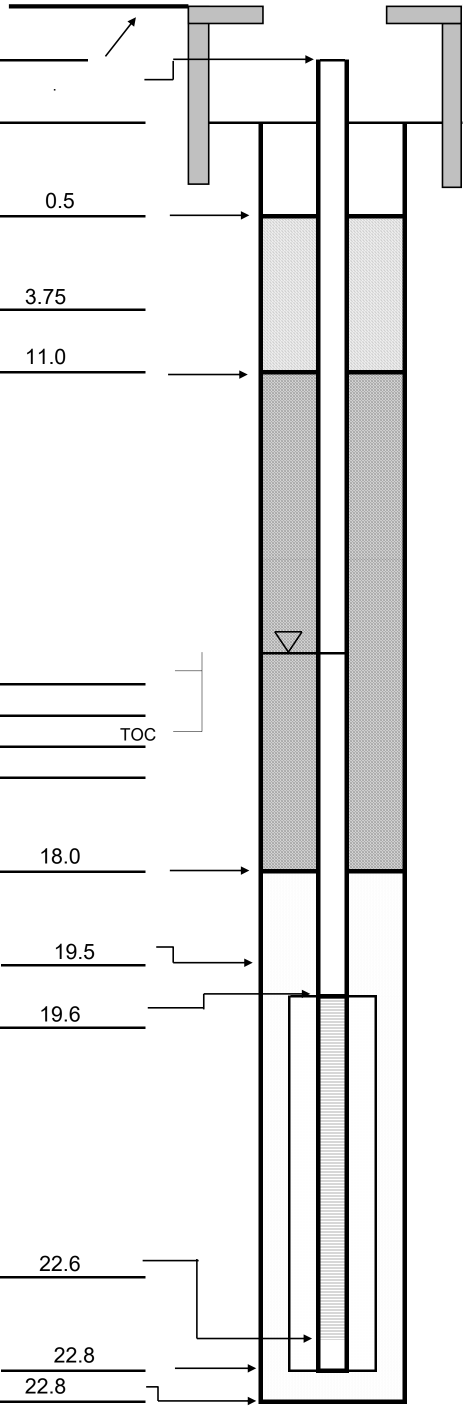
Depths and heights are referenced to ground surface unless specified TOC.

All elevations are referenced to MSL (NAVD 88).

Monitoring Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Air Force Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: PMW-0-2
Site Location: Bldg 324 OU #
Installation Date 6/2/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 0.5
Approximate Diameter of Borehole (in): 3.75
Top of Pellet Seal (ft bgs): 11.0
Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:
Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 18.0
Top of Pre-Pack Assembly (ft bgs): 19.5
Top of Screen Interval (ft bgs): 19.6
Bottom of Screen Interval (ft): 22.6
Bottom of Pre-Pack Assembly (ft): 22.8
Bottom of Borehole (ft): 22.8

Ground Seal (Surface Pad)
Dimensions: 18-inch x 18-inch x 4-inch
Type: Concrete

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co Inc.
Product Name: Pel-Plug TR30
Size: 1/4 inch diameter
Volume Added (ft^3):
Installation: Gravity* Tremie
* throgh the Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1.25 inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.010
Inner Diameter: 1.25"
Outer Diameter: 2.8"
Slot Type: Factory slot

Sump/End Cap: PVC - 0.2-foot
Backfill Material:

APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

APTIM
17 Princess Road
Lawrenceville, NJ 08648

WELL NUMBER STW-1S (renamed PMW-0-3)

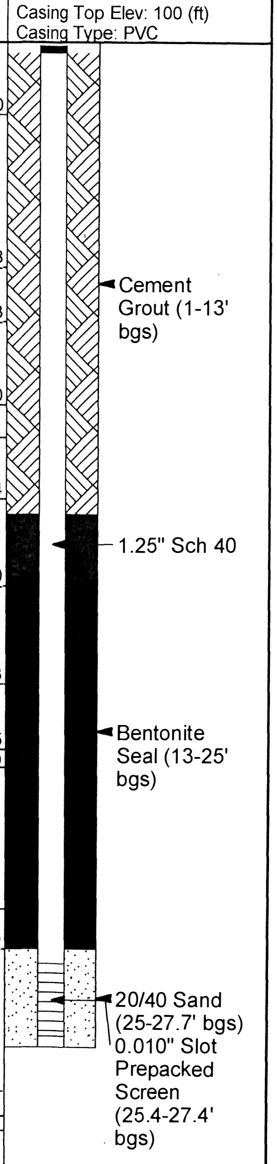
PAGE 1 OF 2

CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC
DATE STARTED 9/5/17 **COMPLETED** 9/5/17
GROUND ELEVATION 100 ft **HOLE SIZE** 3.75 inches
DRILLING CONTRACTOR Cascade
GROUND WATER LEVELS:
DRILLING METHOD Geoprobe
AT TIME OF DRILLING --- 7.7 to 10.0 feet
LOGGED BY M Tucker **CHECKED BY** D Lippincott
AT END OF DRILLING ---
NOTES Description from Boring ESTCP-B01
AFTER DRILLING ---

DEPTH (ft)	U.S.C.S.	MATERIAL DESCRIPTION		
0				
	SP	(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	2.0	98.0
5	SP	(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	6.2	93.8
	SP	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	7.7	92.3
		NO RECOVERY.	10.0	90.0
10	SP	(SP) Medium gray medium SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	10.9	89.1
	SP	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	12.6	87.4
		NO RECOVERY.	15.0	85.0
15	SP	(SP) Light gray fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	17.7	82.3
	SW	(SW) Light gray (speckled white and gray), well-graded SAND and shell hash, with gravel-sized shells, stratified.	19.5	80.5
		NO RECOVERY.	20.0	80.0
20	SW	(SW) SAND with shell hash, same as above.	23.9	76.1
		NO RECOVERY.	25.0	75.0
25	SW	(SW) SAND with shell hash, same as above.	28.9	71.1
	SP	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet, no cementation.	29.6	70.4
		NO RECOVERY.	30.0	70.0
30	SP	(SP) Light gray fine SAND, same as above.	34.5	65.5
		NO RECOVERY.	35.0	65.0
35	CL	(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand.		

WELL DIAGRAM

Casing Top Elev: 100 (ft)
Casing Type: PVC



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WELL NUMBER STW-1S (renamed PMW-0-3)

CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
	CL	▨	(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand. *(continued)* 39.7 — 60.3	
40			NO RECOVERY. 40.0 — 60.0	
	CL	▨	(CL) Gray lean CLAY, same as above. 42.2 — 57.8	
	SW	░	(SW) Light gray fine to coarse SAND with shell hash. 42.4 — 57.6	
	SP	░	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet. 44.6 — 55.4	
45			NO RECOVERY 45.0 — 55.0	
	SP	░	(SP) Light gray fine SAND, same as above. 47.4 — 52.6	
	CL	░	(CL) Band of gray clay. 47.4 — 52.6	
	SP	░	(SP) Light gray medium SAND, dense, wet, homogeneous, no cementation. 49.3 — 50.7	
50			NO RECOVERY. 50.0 — 50.0	

Bottom of borehole at 50.0 feet.

APTIM
17 Princess Road
Lawrenceville, NJ 08648

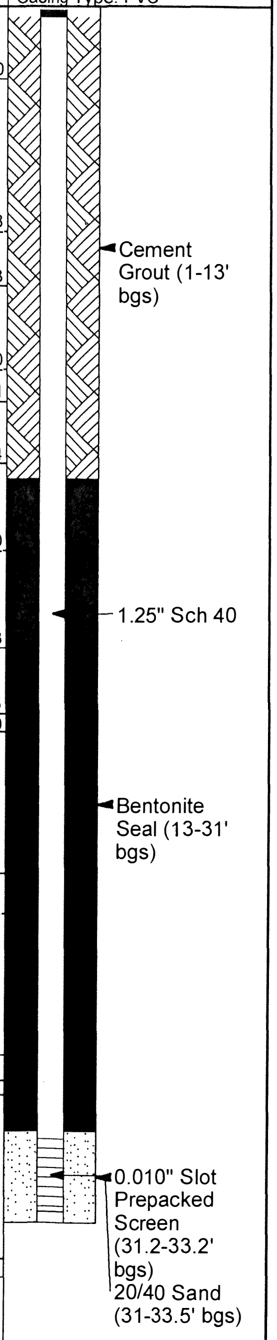
WELL NUMBER STW-1D (renamed PMW-0-4)

CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC
DATE STARTED 9/6/17 **COMPLETED** 9/6/17
GROUND ELEVATION 100 ft **HOLE SIZE** 3.75 inches
DRILLING CONTRACTOR Cascade
GROUND WATER LEVELS:
DRILLING METHOD Geoprobe
AT TIME OF DRILLING --- 7.7 to 10.0 feet
LOGGED BY M Tucker **CHECKED BY** D Lippincott
AT END OF DRILLING ---
NOTES Description from Boring ESTCP-B01
AFTER DRILLING ---

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0				
2.0	SP		(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	98.0
6.2	SP		(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	93.8
7.7	SP		(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	92.3
10.0			NO RECOVERY.	90.0
10.9	SP		(SP) Medium gray medium SAND, poorly-graded (very well-sorted), loose, wet, homogeneous	89.1
12.6	SP		(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous	87.4
15.0			NO RECOVERY.	85.0
17.7	SP		(SP) Light gray fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	82.3
19.5	SW		(SW) Light gray (speckled white and gray), well-graded SAND and shell hash, with gravel-sized shells, stratified.	80.5
20.0			NO RECOVERY.	80.0
23.9	SW		(SW) SAND with shell hash, same as above.	76.1
25.0			NO RECOVERY.	75.0
28.9	SW		(SW) SAND with shell hash, same as above.	71.1
29.6	SP		(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet, no cementation.	70.4
30.0			NO RECOVERY.	70.0
34.5	SP		(SP) Light gray fine SAND, same as above.	65.5
35.0			NO RECOVERY.	65.0
	CL		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand.	

WELL DIAGRAM

Casing Top Elev: 100 (ft)
Casing Type: PVC



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CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION			WELL DIAGRAM
	CL	▨		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand. *(continued)*		
			39.7		60.3	
40			40.0	NO RECOVERY.	60.0	
	CL	▨		(CL) Gray lean CLAY, same as above.		
			42.2		57.8	
	SW	⁘	42.4	(SW) Light gray fine to coarse SAND with shell hash.	57.6	
	SP	░		(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet.		
			44.6		55.4	
45			45.0	NO RECOVERY	55.0	
	SP	░		(SP) Light gray fine SAND, same as above.		
			47.4		52.6	
	CL		47.4	(CL) Band of gray clay.	52.6	
	SP	░		(SP) Light gray medium SAND, dense, wet, homogeneous, no cementation.		
			49.3		50.7	
50			50.0	NO RECOVERY.	50.0	

Bottom of borehole at 50.0 feet.

APTIM
17 Princess Road
Lawrenceville, NJ 08648

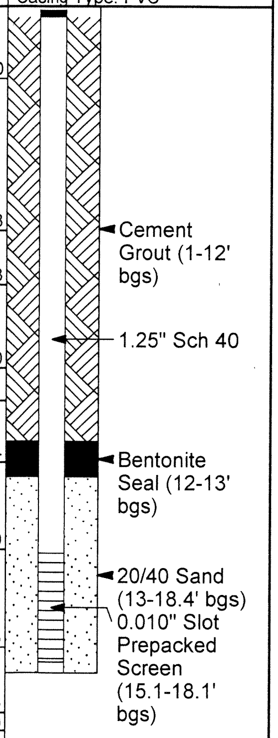
WELL NUMBER PMW-1-1

CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC
DATE STARTED 9/7/17 **COMPLETED** 9/7/17
GROUND ELEVATION 100 ft **HOLE SIZE** 3.75 inches
DRILLING CONTRACTOR Cascade
GROUND WATER LEVELS:
DRILLING METHOD Geoprobe
AT TIME OF DRILLING --- 7.7 to 10.0 feet
LOGGED BY M Tucker **CHECKED BY** D Lippincott
AT END OF DRILLING ---
NOTES Description from Boring ESTCP-B01
AFTER DRILLING ---

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0				
2.0	SP		(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	98.0
6.2	SP		(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	93.8
7.7	SP		(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	92.3
10.0			NO RECOVERY.	90.0
10.9	SP		(SP) Medium gray medium SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	89.1
12.6	SP		(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	87.4
15.0			NO RECOVERY.	85.0
17.7	SP		(SP) Light gray fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	82.3
19.5	SW		(SW) Light gray (speckled white and gray), well-graded SAND and shell hash, with gravel-sized shells, stratified.	80.5
20.0			NO RECOVERY.	80.0
23.9	SW		(SW) SAND with shell hash, same as above.	76.1
25.0			NO RECOVERY.	75.0
28.9	SW		(SW) SAND with shell hash, same as above.	71.1
29.6	SP		(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet, no cementation.	70.4
30.0			NO RECOVERY.	70.0
34.5	SP		(SP) Light gray fine SAND, same as above.	65.5
35.0			NO RECOVERY.	65.0
	CL		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand.	

WELL DIAGRAM

Casing Top Elev: 100 (ft)
Casing Type: PVC



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APTIM
17 Princess Road
Lawrenceville, NJ 08648

WELL NUMBER PMW-1-1

CLIENT ESTCP

PROJECT NUMBER 500814

PROJECT NAME Large Plume

PROJECT LOCATION Myrtle Beach, SC

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION		WELL DIAGRAM
	CL			(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand. *(continued)*		
40			39.7		60.3	
			40.0	NO RECOVERY.	60.0	
	CL			(CL) Gray lean CLAY, same as above.		
			42.2		57.8	
	SW		42.4	(SW) Light gray fine to coarse SAND with shell hash.	57.6	
	SP			(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet.		
45			44.6		55.4	
			45.0	NO RECOVERY	55.0	
	SP			(SP) Light gray fine SAND, same as above.		
			47.4		52.6	
	CL		47.4	(CL) Band of gray clay.	52.6	
	SP			(SP) Light gray medium SAND, dense, wet, homogeneous, no cementation.		
			49.3		50.7	
50			50.0	NO RECOVERY.	50.0	

Bottom of borehole at 50.0 feet.

APTIM
17 Princess Road
Lawrenceville, NJ 08648

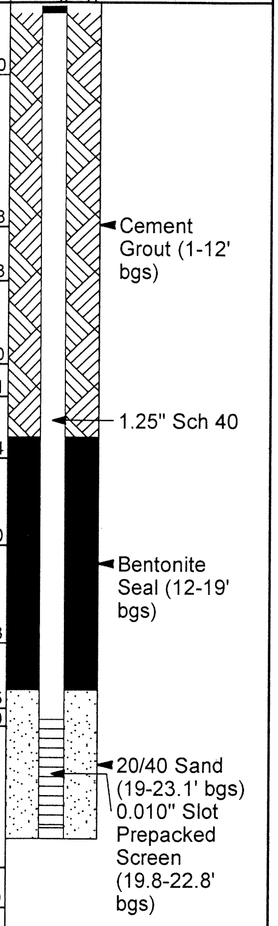
WELL NUMBER PMW-1-2

CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC
DATE STARTED 9/7/17 **COMPLETED** 9/7/17
GROUND ELEVATION 100 ft **HOLE SIZE** 3.75 inches
DRILLING CONTRACTOR Cascade
GROUND WATER LEVELS:
DRILLING METHOD Geoprobe
AT TIME OF DRILLING --- 7.7 to 10.0 feet
LOGGED BY M Tucker **CHECKED BY** D Lippincott
AT END OF DRILLING ---
NOTES Description from Boring ESTCP-B01
AFTER DRILLING ---

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0	SP	2.0	(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	98.0
5	SP	6.2	(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	93.8
	SP	7.7	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	92.3
10		10.0	NO RECOVERY.	90.0
	SP	10.9	(SP) Medium gray medium SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	89.1
	SP	12.6	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	87.4
15		15.0	NO RECOVERY.	85.0
	SP	17.7	(SP) Light gray fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	82.3
	SW	19.5	(SW) Light gray (speckled white and gray), well-graded SAND and shell hash, with gravel-sized shells, stratified.	80.5
20		20.0	NO RECOVERY.	80.0
	SW	23.9	(SW) SAND with shell hash, same as above.	76.1
25		25.0	NO RECOVERY.	75.0
	SW	28.9	(SW) SAND with shell hash, same as above.	71.1
	SP	29.6	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet, no cementation.	70.4
30		30.0	NO RECOVERY.	70.0
	SP	34.5	(SP) Light gray fine SAND, same as above.	65.5
35		35.0	NO RECOVERY.	65.0
	CL		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand.	

WELL DIAGRAM

Casing Top Elev: 100 (ft)
Casing Type: PVC



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APTIM
17 Princess Road
Lawrenceville, NJ 08648

WELL NUMBER PMW-1-2

PAGE 2 OF 2

CLIENT ESTCP

PROJECT NAME Large Plume

PROJECT NUMBER 500814

PROJECT LOCATION Myrtle Beach, SC

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
	CL	▨	(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand. *(continued)* 39.7 60.3	
40			NO RECOVERY. 40.0 60.0	
	CL	▨	(CL) Gray lean CLAY, same as above. 42.2 57.8	
	SW	⁘	(SW) Light gray fine to coarse SAND with shell hash. 42.4 57.6	
	SP	⁚	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet. 44.6 55.4	
45			NO RECOVERY 45.0 55.0	
	SP	⁚	(SP) Light gray fine SAND, same as above. 47.4 52.6	
	CL	⁚	(CL) Band of gray clay. 47.4 52.6	
	SP	⁚	(SP) Light gray medium SAND, dense, wet, homogeneous, no cementation. 49.3 50.7	
50			NO RECOVERY. 50.0 50.0	

Bottom of borehole at 50.0 feet.

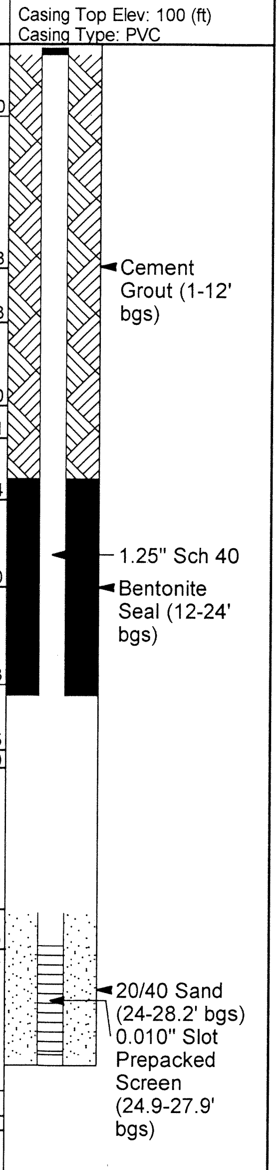
APTIM
17 Princess Road
Lawrenceville, NJ 08648

WELL NUMBER PMW-1-3

CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC
DATE STARTED 9/8/17 **COMPLETED** 9/8/17
GROUND ELEVATION 100 ft **HOLE SIZE** 3.75 inches
DRILLING CONTRACTOR Cascade
GROUND WATER LEVELS:
DRILLING METHOD Geoprobe
AT TIME OF DRILLING --- 7.7 to 10.0 feet
LOGGED BY M Tucker **CHECKED BY** D Lippincott
AT END OF DRILLING ---
NOTES Description from Boring ESTCP-B01
AFTER DRILLING ---

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0	SP	2.0	(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	98.0
5	SP	6.2	(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	93.8
	SP	7.7	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	92.3
10		10.0	NO RECOVERY.	90.0
	SP	10.9	(SP) Medium gray medium SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	89.1
	SP	12.6	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	87.4
15		15.0	NO RECOVERY.	85.0
	SP	17.7	(SP) Light gray fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	82.3
	SW	19.5	(SW) Light gray (speckled white and gray), well-graded SAND and shell hash, with gravel-sized shells, stratified.	80.5
20		20.0	NO RECOVERY.	80.0
	SW	23.9	(SW) SAND with shell hash, same as above.	76.1
25		25.0	NO RECOVERY.	75.0
	SW	28.9	(SW) SAND with shell hash, same as above.	71.1
	SP	29.6	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet, no cementation.	70.4
30		30.0	NO RECOVERY.	70.0
	SP	34.5	(SP) Light gray fine SAND, same as above.	65.5
35		35.0	NO RECOVERY.	65.0
	CL		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand.	

WELL DIAGRAM



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WELL NUMBER PMW-1-3

CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION		WELL DIAGRAM
	CL	▨		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand. *(continued)*		
40			39.7		60.3	
			40.0	NO RECOVERY.	60.0	
	CL	▨		(CL) Gray lean CLAY, same as above.		
			42.2		57.8	
	SW	░	42.4	(SW) Light gray fine to coarse SAND with shell hash.	57.6	
	SP	░		(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet.		
45			44.6		55.4	
			45.0	NO RECOVERY	55.0	
	SP	░		(SP) Light gray fine SAND, same as above.		
			47.4		52.6	
	CL	░	47.4	(CL) Band of gray clay.	52.6	
	SP	░		(SP) Light gray medium SAND, dense, wet, homogeneous, no cementation.		
			49.3		50.7	
50			50.0	NO RECOVERY.	50.0	

Bottom of borehole at 50.0 feet.

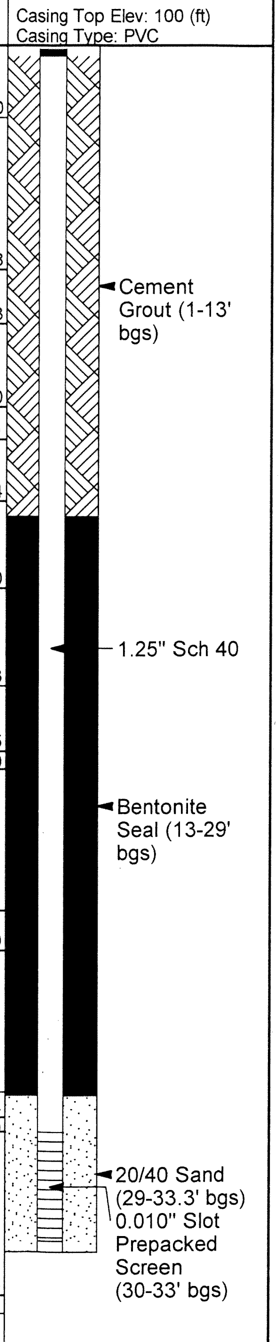
APTIM
17 Princess Road
Lawrenceville, NJ 08648

WELL NUMBER PMW-1-4

CLIENT	ESTCP	**PROJECT NAME**	Large Plume
PROJECT NUMBER	500814	**PROJECT LOCATION**	Myrtle Beach, SC
DATE STARTED	9/21/17	**COMPLETED**	9/21/17
GROUND ELEVATION	100 ft	**HOLE SIZE**	3.75 inches
DRILLING CONTRACTOR	Cascade	**GROUND WATER LEVELS:**	
DRILLING METHOD	Geoprobe	**AT TIME OF DRILLING**	--- 7.7 to 10.0 feet
LOGGED BY	M Tucker	**CHECKED BY**	D Lippincott
AT END OF DRILLING	---	**AFTER DRILLING**	---
NOTES	Description from Boring ESTCP-B01		

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0	SP	2.0	(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	98.0
5	SP	6.2	(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	93.8
	SP	7.7	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	92.3
10		10.0	NO RECOVERY.	90.0
	SP	10.9	(SP) Medium gray medium SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	89.1
	SP	12.6	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	87.4
15		15.0	NO RECOVERY.	85.0
	SP	17.7	(SP) Light gray fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	82.3
	SW	19.5	(SW) Light gray (speckled white and gray), well-graded SAND and shell hash, with gravel-sized shells, stratified.	80.5
20		20.0	NO RECOVERY.	80.0
	SW	23.9	(SW) SAND with shell hash, same as above.	76.1
25		25.0	NO RECOVERY.	75.0
	SW	28.9	(SW) SAND with shell hash, same as above.	71.1
30	SP	29.6	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet, no cementation.	70.4
		30.0	NO RECOVERY.	70.0
	SP	34.5	(SP) Light gray fine SAND, same as above.	65.5
35		35.0	NO RECOVERY.	65.0
	CL		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand.	

WELL DIAGRAM



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WELL NUMBER PMW-1-4

CLIENT ESTCP

PROJECT NAME Large Plume

PROJECT NUMBER 500814

PROJECT LOCATION Myrtle Beach, SC

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION		WELL DIAGRAM
	CL	▨	39.7	(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand. *(continued)*	60.3	
40			40.0	NO RECOVERY.	60.0	
	CL	▨	42.2	(CL) Gray lean CLAY, same as above.	57.8	
	SW	░	42.4	(SW) Light gray fine to coarse SAND with shell hash.	57.6	
	SP	░	44.6	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet.	55.4	
45			45.0	NO RECOVERY	55.0	
	SP	░	47.4	(SP) Light gray fine SAND, same as above.	52.6	
	CL	░	47.4	(CL) Band of gray clay.	52.6	
	SP	░	49.3	(SP) Light gray medium SAND, dense, wet, homogeneous, no cementation.	50.7	
50			50.0	NO RECOVERY.	50.0	

Bottom of borehole at 50.0 feet.

APTIM
17 Princess Road
Lawrenceville, NJ 08648

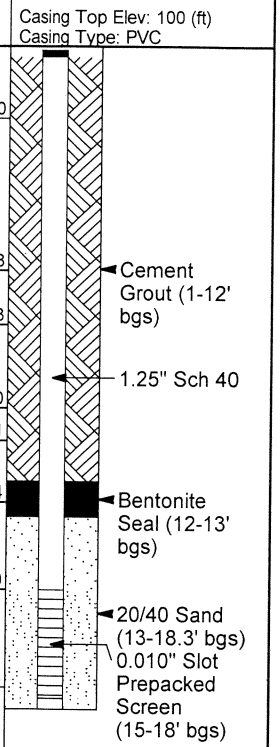
WELL NUMBER PMW-2-1

PAGE 1 OF 2

CLIENT	ESTCP	**PROJECT NAME**	Large Plume
PROJECT NUMBER	500814	**PROJECT LOCATION**	Myrtle Beach, SC
DATE STARTED	9/7/17 **COMPLETED** 9/7/17	**GROUND ELEVATION**	100 ft **HOLE SIZE** 3.75 inches
DRILLING CONTRACTOR	Cascade	**GROUND WATER LEVELS:**	
DRILLING METHOD	Geoprobe	**AT TIME OF DRILLING**	--- 7.7 to 10.0 feet
LOGGED BY	M Tucker **CHECKED BY** D Lippincott	**AT END OF DRILLING**	---
NOTES	Description from Boring ESTCP-B01	**AFTER DRILLING**	---

DEPTH (ft)	U.S.C.S.	MATERIAL DESCRIPTION	
2.0	SP	(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	98.0
6.2	SP	(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	93.8
7.7	SP	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	92.3
10.0		NO RECOVERY.	90.0
10.9	SP	(SP) Medium gray medium SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	89.1
12.6	SP	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	87.4
15.0		NO RECOVERY.	85.0
17.7	SP	(SP) Light gray fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	82.3
19.5	SW	(SW) Light gray (speckled white and gray), well-graded SAND and shell hash, with gravel-sized shells, stratified.	80.5
20.0		NO RECOVERY.	80.0
23.9	SW	(SW) SAND with shell hash, same as above.	76.1
25.0		NO RECOVERY.	75.0
28.9	SW	(SW) SAND with shell hash, same as above.	71.1
29.6	SP	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet, no cementation.	70.4
30.0		NO RECOVERY.	70.0
34.5	SP	(SP) Light gray fine SAND, same as above.	65.5
35.0		NO RECOVERY.	65.0
	CL	(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand.	

WELL DIAGRAM



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CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION		WELL DIAGRAM
	CL	▨		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand. *(continued)*		
40			39.7 40.0	NO RECOVERY.	60.3 60.0	
	CL	▨	42.2	(CL) Gray lean CLAY, same as above.	57.8	
	SW	∴	42.4	(SW) Light gray fine to coarse SAND with shell hash.	57.6	
	SP	░	44.6	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet.	55.4	
45			45.0	NO RECOVERY	55.0	
	SP	░	47.4	(SP) Light gray fine SAND, same as above.	52.6	
	CL	░	47.4	(CL) Band of gray clay.	52.6	
	SP	░	49.3	(SP) Light gray medium SAND, dense, wet, homogeneous, no cementation.	50.7	
50			50.0	NO RECOVERY.	50.0	

Bottom of borehole at 50.0 feet.

APTIM
17 Princess Road
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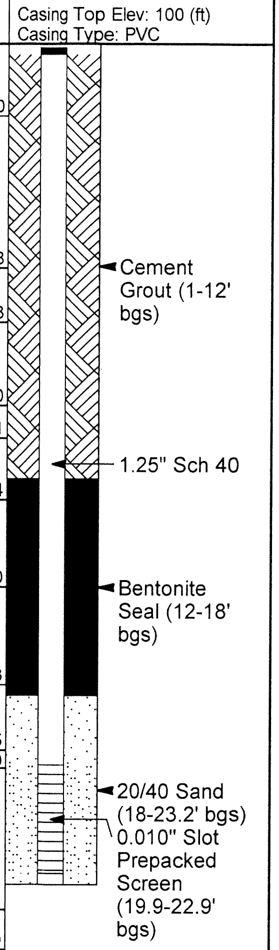
WELL NUMBER PMW-2-2

PAGE 1 OF 2

CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC
DATE STARTED 9/7/17 **COMPLETED** 9/7/17
GROUND ELEVATION 100 ft **HOLE SIZE** 3.75 inches
DRILLING CONTRACTOR Cascade
GROUND WATER LEVELS:
DRILLING METHOD Geoprobe
AT TIME OF DRILLING --- 7.7 to 10.0 feet
LOGGED BY M Tucker **CHECKED BY** D Lippincott
AT END OF DRILLING ---
NOTES Description from Boring ESTCP-B01
AFTER DRILLING ---

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0	SP	2.0	(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	98.0
5	SP	6.2	(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	93.8
	SP	7.7	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	92.3
10		10.0	NO RECOVERY.	90.0
	SP	10.9	(SP) Medium gray medium SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	89.1
	SP	12.6	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	87.4
15		15.0	NO RECOVERY.	85.0
	SP	17.7	(SP) Light gray fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	82.3
	SW	19.5	(SW) Light gray (speckled white and gray), well-graded SAND and shell hash, with gravel-sized shells, stratified.	80.5
20		20.0	NO RECOVERY.	80.0
	SW	23.9	(SW) SAND with shell hash, same as above.	76.1
25		25.0	NO RECOVERY.	75.0
	SW	28.9	(SW) SAND with shell hash, same as above.	71.1
	SP	29.6	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet, no cementation.	70.4
30		30.0	NO RECOVERY.	70.0
	SP	34.5	(SP) Light gray fine SAND, same as above.	65.5
35		35.0	NO RECOVERY.	65.0
	CL		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand.	

WELL DIAGRAM



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17 Princess Road
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WELL NUMBER PMW-2-2

PAGE 2 OF 2

CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION		WELL DIAGRAM
	CL	▨	39.7	(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand. *(continued)*	60.3	
40			40.0	NO RECOVERY.	60.0	
	CL	▨	42.2	(CL) Gray lean CLAY, same as above.	57.8	
	SW	░	42.4	(SW) Light gray fine to coarse SAND with shell hash.	57.6	
	SP	░	44.6	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet.	55.4	
45			45.0	NO RECOVERY	55.0	
	SP	░	47.4	(SP) Light gray fine SAND, same as above.	52.6	
	CL	░	47.4	(CL) Band of gray clay.	52.6	
	SP	░	49.3	(SP) Light gray medium SAND, dense, wet, homogeneous, no cementation.	50.7	
50			50.0	NO RECOVERY.	50.0	

Bottom of borehole at 50.0 feet.

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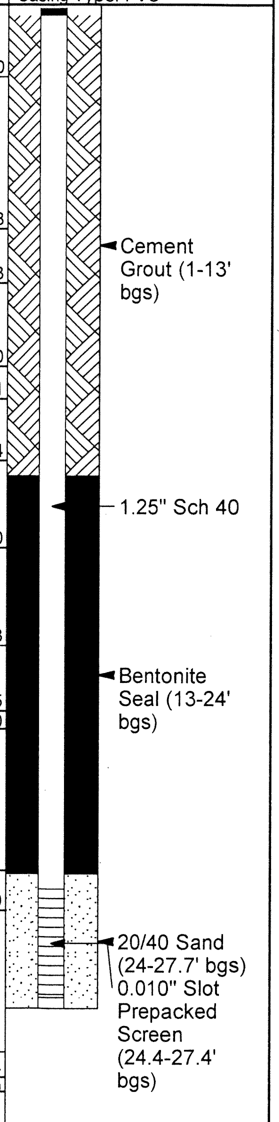
WELL NUMBER PMW-2-3

CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC
DATE STARTED 9/19/17 **COMPLETED** 9/19/17
GROUND ELEVATION 100 ft **HOLE SIZE** 3.75 inches
DRILLING CONTRACTOR Cascade
GROUND WATER LEVELS:
DRILLING METHOD Geoprobe
AT TIME OF DRILLING --- 7.7 to 10.0 feet
LOGGED BY M Tucker **CHECKED BY** D Lippincott
AT END OF DRILLING ---
NOTES Description from Boring ESTCP-B01
AFTER DRILLING ---

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION		
0	SP		(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	2.0	98.0
5	SP		(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	6.2	93.8
	SP		(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	7.7	92.3
10			NO RECOVERY.	10.0	90.0
	SP		(SP) Medium gray medium SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	10.9	89.1
	SP		(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	12.6	87.4
15			NO RECOVERY.	15.0	85.0
	SP		(SP) Light gray fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	17.7	82.3
	SW		(SW) Light gray (speckled white and gray), well-graded SAND and shell hash, with gravel-sized shells, stratified.	19.5	80.5
20			NO RECOVERY.	20.0	80.0
	SW		(SW) SAND with shell hash, same as above.	23.9	76.1
25			NO RECOVERY.	25.0	75.0
	SW		(SW) SAND with shell hash, same as above.	28.9	71.1
	SP		(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet, no cementation.	29.6	70.4
30			NO RECOVERY.	30.0	70.0
	SP		(SP) Light gray fine SAND, same as above.	34.5	65.5
35			NO RECOVERY.	35.0	65.0
	CL		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand.		

WELL DIAGRAM

Casing Top Elev: 100 (ft)
Casing Type: PVC



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APTIM
17 Princess Road
Lawrenceville, NJ 08648

WELL NUMBER PMW-2-3

CLIENT ESTCP

PROJECT NAME Large Plume

PROJECT NUMBER 500814

PROJECT LOCATION Myrtle Beach, SC

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION		WELL DIAGRAM
	CL	▨	39.7	(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand. *(continued)*	60.3	
40			40.0	NO RECOVERY.	60.0	
	CL	▨	42.2	(CL) Gray lean CLAY, same as above.	57.8	
	SW	░	42.4	(SW) Light gray fine to coarse SAND with shell hash.	57.6	
	SP	░	44.6	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet.	55.4	
45			45.0	NO RECOVERY	55.0	
	SP	░	47.4	(SP) Light gray fine SAND, same as above.	52.6	
	CL	░	47.4	(CL) Band of gray clay.	52.6	
	SP	░	49.3	(SP) Light gray medium SAND, dense, wet, homogeneous, no cementation.	50.7	
50			50.0	NO RECOVERY.	50.0	

Bottom of borehole at 50.0 feet.

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Lawrenceville, NJ 08648

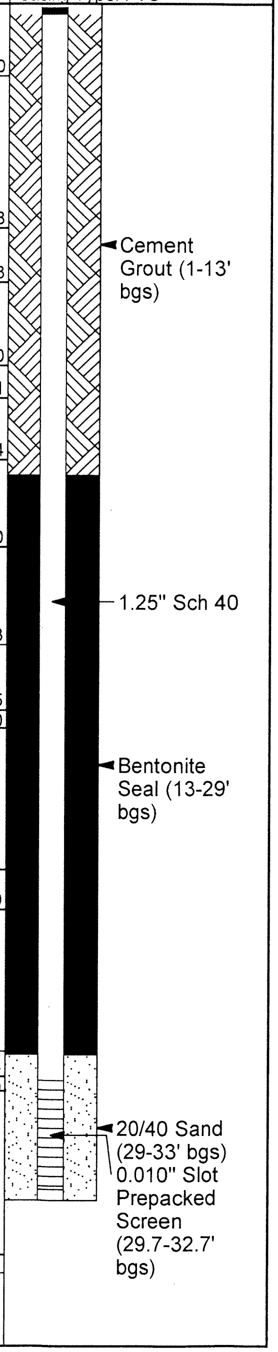
WELL NUMBER PMW-2-4

CLIENT ESTCP	**PROJECT NAME** Large Plume
PROJECT NUMBER 500814	**PROJECT LOCATION** Myrtle Beach, SC
DATE STARTED 9/20/17 **COMPLETED** 9/20/17	**GROUND ELEVATION** 100 ft **HOLE SIZE** 3.75 inches
DRILLING CONTRACTOR Cascade	**GROUND WATER LEVELS:**
DRILLING METHOD Geoprobe	**AT TIME OF DRILLING** --- 7.7 to 10.0 feet
LOGGED BY M Tucker **CHECKED BY** D Lippincott	**AT END OF DRILLING** ---
NOTES Description from Boring ESTCP-B01	**AFTER DRILLING** ---

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0	SP	2.0	(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	98.0
5	SP	6.2	(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	93.8
	SP	7.7	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	92.3
		10.0	NO RECOVERY.	90.0
10	SP	10.9	(SP) Medium gray medium SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	89.1
	SP	12.6	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	87.4
		15.0	NO RECOVERY.	85.0
15	SP	17.7	(SP) Light gray fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	82.3
	SW	19.5	(SW) Light gray (speckled white and gray), well-graded SAND and shell hash, with gravel-sized shells, stratified.	80.5
		20.0	NO RECOVERY.	80.0
20	SW	23.9	(SW) SAND with shell hash, same as above.	76.1
		25.0	NO RECOVERY.	75.0
25	SW	28.9	(SW) SAND with shell hash, same as above.	71.1
	SP	29.6	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet, no cementation.	70.4
		30.0	NO RECOVERY.	70.0
30	SP	34.5	(SP) Light gray fine SAND, same as above.	65.5
		35.0	NO RECOVERY.	65.0
35	CL		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand.	

WELL DIAGRAM

Casing Top Elev: 100 (ft)
Casing Type: PVC



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WELL NUMBER PMW-2-4

CLIENT ESTCP
PROJECT NUMBER 500814
PROJECT NAME Large Plume
PROJECT LOCATION Myrtle Beach, SC

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION		WELL DIAGRAM
	CL	▨	39.7	(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand. *(continued)*	60.3	
40			40.0	NO RECOVERY.	60.0	
	CL	▨	42.2	(CL) Gray lean CLAY, same as above.	57.8	
	SW	⁘	42.4	(SW) Light gray fine to coarse SAND with shell hash.	57.6	
	SP	░	44.6	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet.	55.4	
45			45.0	NO RECOVERY	55.0	
	SP	░	47.4	(SP) Light gray fine SAND, same as above.	52.6	
	CL	░	47.4	(CL) Band of gray clay.	52.6	
	SP	░	49.3	(SP) Light gray medium SAND, dense, wet, homogeneous, no cementation.	50.7	
50			50.0	NO RECOVERY.	50.0	

Bottom of borehole at 50.0 feet.

APTIM
17 Princess Road
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WELL NUMBER PMW-3-1

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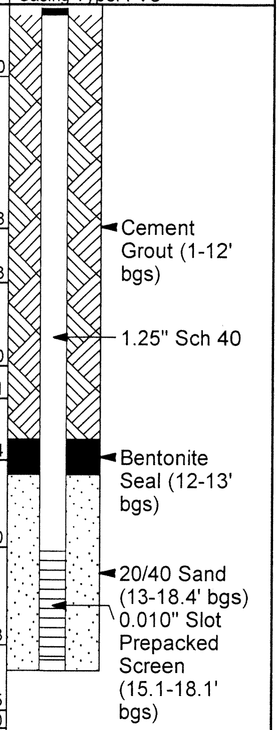
CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC
DATE STARTED 9/7/17 **COMPLETED** 9/7/17
GROUND ELEVATION 100 ft **HOLE SIZE** 3.75 inches
DRILLING CONTRACTOR Cascade
GROUND WATER LEVELS:
DRILLING METHOD Geoprobe
AT TIME OF DRILLING --- 7.7 to 10.0 feet
LOGGED BY M Tucker **CHECKED BY** D Lippincott
AT END OF DRILLING ---
NOTES Description from Boring ESTCP-B01
AFTER DRILLING ---

DEPTH (ft)	U.S.C.S.	MATERIAL DESCRIPTION	
0 – 2.0	SP	(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	98.0
2.0 – 6.2	SP	(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	93.8
6.2 – 7.7	SP	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	92.3
7.7 – 10.0		NO RECOVERY.	90.0
10.0 – 10.9	SP	(SP) Medium gray medium SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	89.1
10.9 – 12.6	SP	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	87.4
12.6 – 15.0		NO RECOVERY.	85.0
15.0 – 17.7	SP	(SP) Light gray fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	82.3
17.7 – 19.5	SW	(SW) Light gray (speckled white and gray), well-graded SAND and shell hash, with gravel-sized shells, stratified.	80.5
19.5 – 20.0		NO RECOVERY.	80.0
20.0 – 23.9	SW	(SW) SAND with shell hash, same as above.	76.1
23.9 – 25.0		NO RECOVERY.	75.0
25.0 – 28.9	SW	(SW) SAND with shell hash, same as above.	71.1
28.9 – 29.6	SP	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet, no cementation.	70.4
29.6 – 30.0		NO RECOVERY.	70.0
30.0 – 34.5	SP	(SP) Light gray fine SAND, same as above.	65.5
34.5 – 35.0		NO RECOVERY.	65.0
35.0 –	CL	(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand.	

WELL DIAGRAM

Casing Top Elev: 100 (ft)
Casing Type: PVC



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APTIM
17 Princess Road
Lawrenceville, NJ 08648

WELL NUMBER PMW-3-1

CLIENT ESTCP

PROJECT NAME Large Plume

PROJECT NUMBER 500814

PROJECT LOCATION Myrtle Beach, SC

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION		WELL DIAGRAM
	CL			(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand. *(continued)*		
40			39.7		60.3	
			40.0	NO RECOVERY.	60.0	
	CL			(CL) Gray lean CLAY, same as above.		
			42.2		57.8	
	SW		42.4	(SW) Light gray fine to coarse SAND with shell hash.	57.6	
	SP			(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet.		
			44.6		55.4	
45			45.0	NO RECOVERY	55.0	
	SP			(SP) Light gray fine SAND, same as above.		
			47.4		52.6	
	CL		47.4	(CL) Band of gray clay.	52.6	
	SP			(SP) Light gray medium SAND, dense, wet, homogeneous, no cementation.		
			49.3		50.7	
50			50.0	NO RECOVERY.	50.0	

Bottom of borehole at 50.0 feet.

APTIM
17 Princess Road
Lawrenceville, NJ 08648

WELL NUMBER PMW-3-2

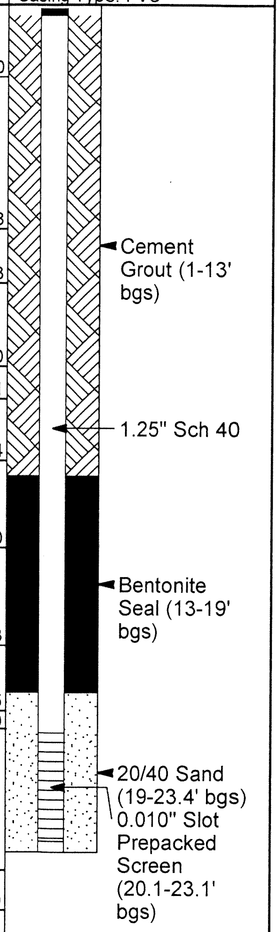
PAGE 1 OF 2

CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC
DATE STARTED 9/8/17 **COMPLETED** 9/8/17
GROUND ELEVATION 100 ft **HOLE SIZE** 3.75 inches
DRILLING CONTRACTOR Cascade
GROUND WATER LEVELS:
DRILLING METHOD Geoprobe
AT TIME OF DRILLING --- 7.7 to 10.0 feet
LOGGED BY M Tucker **CHECKED BY** D Lippincott
AT END OF DRILLING ---
NOTES Description from Boring ESTCP-B01
AFTER DRILLING ---

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0	SP	2.0	(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	98.0
5	SP	6.2	(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	93.8
	SP	7.7	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	92.3
10		10.0	NO RECOVERY.	90.0
	SP	10.9	(SP) Medium gray medium SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	89.1
	SP	12.6	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	87.4
15		15.0	NO RECOVERY.	85.0
	SP	17.7	(SP) Light gray fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	82.3
	SW	19.5	(SW) Light gray (speckled white and gray), well-graded SAND and shell hash, with gravel-sized shells, stratified.	80.5
20		20.0	NO RECOVERY.	80.0
	SW	23.9	(SW) SAND with shell hash, same as above.	76.1
25		25.0	NO RECOVERY.	75.0
	SW	28.9	(SW) SAND with shell hash, same as above.	71.1
	SP	29.6	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet, no cementation.	70.4
30		30.0	NO RECOVERY.	70.0
	SP	34.5	(SP) Light gray fine SAND, same as above.	65.5
35		35.0	NO RECOVERY.	65.0
	CL		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand.	

WELL DIAGRAM

Casing Top Elev: 100 (ft)
Casing Type: PVC



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CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION		WELL DIAGRAM
	CL	▨		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand. *(continued)*		
40			39.7 40.0	NO RECOVERY.	60.3 60.0	
	CL	▨		(CL) Gray lean CLAY, same as above.		
			42.2		57.8	
	SW	∴	42.4	(SW) Light gray fine to coarse SAND with shell hash.	57.6	
	SP	∴		(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet.		
45			44.6 45.0	NO RECOVERY	55.4 55.0	
	SP	∴		(SP) Light gray fine SAND, same as above.		
			47.4		52.6	
	CL	∴	47.4	(CL) Band of gray clay.	52.6	
	SP	∴		(SP) Light gray medium SAND, dense, wet, homogeneous, no cementation.		
			49.3		50.7	
50			50.0	NO RECOVERY.	50.0	

Bottom of borehole at 50.0 feet.

APTIM
17 Princess Road
Lawrenceville, NJ 08648

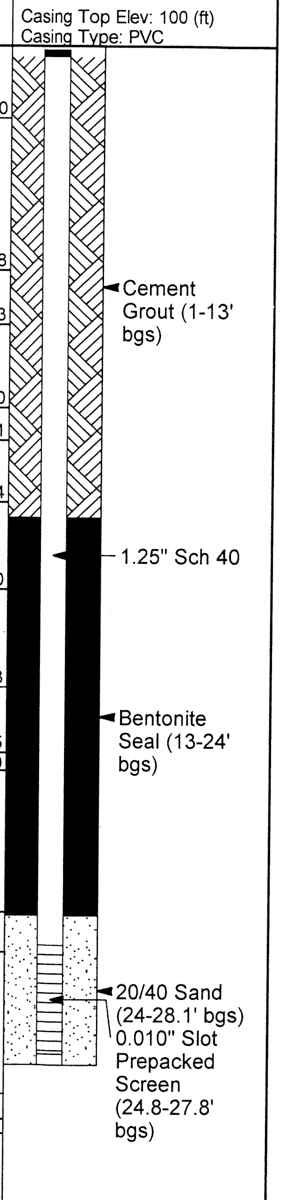
WELL NUMBER PMW-3-3

PAGE 1 OF 2

CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC
DATE STARTED 9/20/17 **COMPLETED** 9/20/17
GROUND ELEVATION 100 ft **HOLE SIZE** 3.75 inches
DRILLING CONTRACTOR Cascade
GROUND WATER LEVELS:
DRILLING METHOD Geoprobe
AT TIME OF DRILLING --- 7.7 to 10.0 feet
LOGGED BY M Tucker **CHECKED BY** D Lippincott
AT END OF DRILLING ---
NOTES Description from Boring ESTCP-B01
AFTER DRILLING ---

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0	SP	2.0	(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	98.0
5	SP	6.2	(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	93.8
	SP	7.7	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	92.3
		10.0	NO RECOVERY.	90.0
10	SP	10.9	(SP) Medium gray medium SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	89.1
	SP	12.6	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	87.4
		15.0	NO RECOVERY.	85.0
15	SP	17.7	(SP) Light gray fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	82.3
	SW	19.5	(SW) Light gray (speckled white and gray), well-graded SAND and shell hash, with gravel-sized shells, stratified.	80.5
		20.0	NO RECOVERY.	80.0
20	SW	23.9	(SW) SAND with shell hash, same as above.	76.1
		25.0	NO RECOVERY.	75.0
25	SW	28.9	(SW) SAND with shell hash, same as above.	71.1
	SP	29.6	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet, no cementation.	70.4
		30.0	NO RECOVERY.	70.0
30	SP	34.5	(SP) Light gray fine SAND, same as above.	65.5
		35.0	NO RECOVERY.	65.0
35	CL		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand.	

WELL DIAGRAM



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APTIM
17 Princess Road
Lawrenceville, NJ 08648

WELL NUMBER PMW-3-3

CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION		WELL DIAGRAM
	CL	▨		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand. *(continued)*		
40			39.7 40.0	NO RECOVERY.	60.3 60.0	
	CL	▨		(CL) Gray lean CLAY, same as above.		
	SW	∴	42.2 42.4	(SW) Light gray fine to coarse SAND with shell hash.	57.8 57.6	
	SP	∴		(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet.		
45			44.6 45.0	NO RECOVERY	55.4 55.0	
	SP	∴		(SP) Light gray fine SAND, same as above.		
	CL	∴	47.4 47.4	(CL) Band of gray clay.	52.6 52.6	
	SP	∴		(SP) Light gray medium SAND, dense, wet, homogeneous, no cementation.		
50			49.3 50.0	NO RECOVERY.	50.7 50.0	

Bottom of borehole at 50.0 feet.

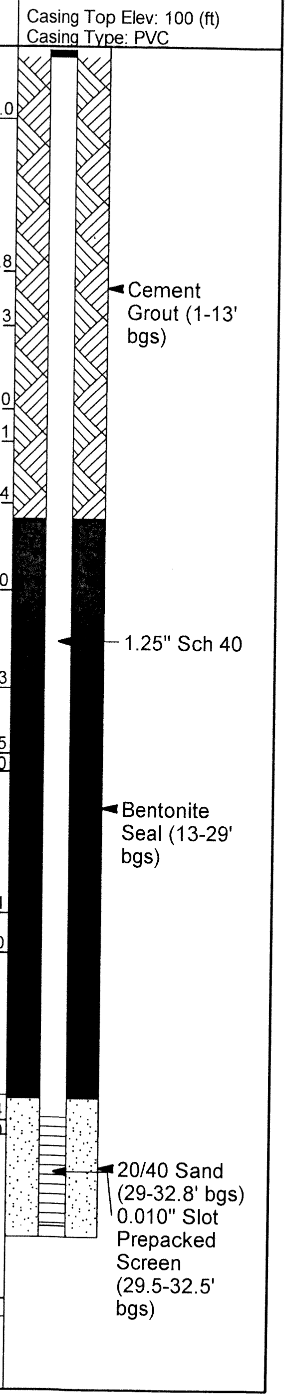
APTIM
17 Princess Road
Lawrenceville, NJ 08648

WELL NUMBER PMW-3-4

CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC
DATE STARTED 9/20/17 **COMPLETED** 9/20/17
GROUND ELEVATION 100 ft **HOLE SIZE** 3.75 inches
DRILLING CONTRACTOR Cascade
GROUND WATER LEVELS:
DRILLING METHOD Geoprobe
AT TIME OF DRILLING --- 7.7 to 10.0 feet
LOGGED BY M Tucker **CHECKED BY** D Lippincott
AT END OF DRILLING ---
NOTES Description from Boring ESTCP-B01
AFTER DRILLING ---

DEPTH (ft)	U.S.C.S.	MATERIAL DESCRIPTION	Bottom depth (ft)	Elevation (ft)
0	SP	(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	2.0	98.0
	SP	(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	6.2	93.8
5	SP	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	7.7	92.3
		NO RECOVERY.	10.0	90.0
10	SP	(SP) Medium gray medium SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	10.9	89.1
	SP	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	12.6	87.4
		NO RECOVERY.	15.0	85.0
15	SP	(SP) Light gray fine SAND, poorly-graded (very well-sorted), loose, wet, homogeneous.	17.7	82.3
	SW	(SW) Light gray (speckled white and gray), well-graded SAND and shell hash, with gravel-sized shells, stratified.	19.5	80.5
		NO RECOVERY.	20.0	80.0
20	SW	(SW) SAND with shell hash, same as above.	23.9	76.1
		NO RECOVERY.	25.0	75.0
25	SW	(SW) SAND with shell hash, same as above.	28.9	71.1
	SP	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet, no cementation.	29.6	70.4
		NO RECOVERY.	30.0	70.0
30	SP	(SP) Light gray fine SAND, same as above.	34.5	65.5
		NO RECOVERY.	35.0	65.0
35	CL	(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand.		

WELL DIAGRAM



(Continued Next Page)

APTIM
17 Princess Road
Lawrenceville, NJ 08648

WELL NUMBER PMW-3-4

PAGE 2 OF 2

CLIENT ESTCP

PROJECT NAME Large Plume

PROJECT NUMBER 500814

PROJECT LOCATION Myrtle Beach, SC

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION		WELL DIAGRAM
	CL	▨		(CL) Gray lean CLAY, firm, moist, low plasticity, medium dry strength, no dilatancy, contains several thin (1/4 inch) bands of white fine sand. *(continued)*		
40			39.7	NO RECOVERY.	60.3	
	CL	▨	40.0	(CL) Gray lean CLAY, same as above.	60.0	
	SW	░	42.2	(SW) Light gray fine to coarse SAND with shell hash.	57.8	
	SP	░	42.4	(SP) Light gray fine SAND, poorly-graded (well-sorted), dense, wet.	57.6	
45			44.6	NO RECOVERY	55.4	
	SP	░	45.0	(SP) Light gray fine SAND, same as above.	55.0	
	CL	░	47.4	(CL) Band of gray clay.	52.6	
	SP	░	47.4	(SP) Light gray medium SAND, dense, wet, homogeneous, no cementation.	52.6	
50			49.3 50.0	NO RECOVERY.	50.7 50.0	

Bottom of borehole at 50.0 feet.

WELL - GINT STD US LAB.GDT - 10/9/17 09:13 - R:\PROJECTS\500814-ESTCP LARGE DILUTE PLUME\BORING LOGS\MYRTLE.GPJ

APTIM
17 Princess Road
Lawrenceville, NJ 08648

WELL NUMBER VP-1

PAGE 1 OF 1

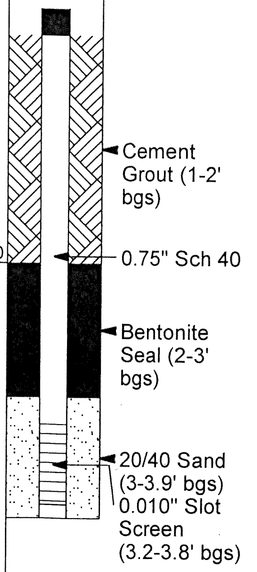
CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC
DATE STARTED 9/19/17 **COMPLETED** 9/19/17
GROUND ELEVATION 100 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Cascade
GROUND WATER LEVELS:
DRILLING METHOD Geoprobe
AT TIME OF DRILLING --- 7.7 to 10.0 feet
LOGGED BY M Tucker **CHECKED BY** D Lippincott
AT END OF DRILLING ---
NOTES Description from Boring ESTCP-B01
AFTER DRILLING ---

DEPTH (ft)	U.S.C.S.	MATERIAL DESCRIPTION	Elevation
0.0	SP	(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	
2.0	SP	(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	98.0
6.2	SP	(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	93.8
7.7		NO RECOVERY.	92.3
10.0			90.0

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0

WELL DIAGRAM

Casing Top Elev: 100 (ft)
Casing Type: PVC



APTIM
17 Princess Road
Lawrenceville, NJ 08648

WELL NUMBER VP-2

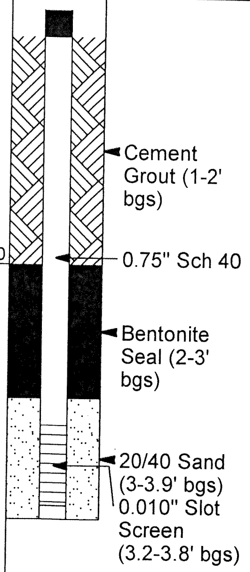
PAGE 1 OF 1

CLIENT ESTCP
PROJECT NAME Large Plume
PROJECT NUMBER 500814
PROJECT LOCATION Myrtle Beach, SC
DATE STARTED 9/19/17 **COMPLETED** 9/19/17
GROUND ELEVATION 100 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Cascade
GROUND WATER LEVELS:
DRILLING METHOD Geoprobe
AT TIME OF DRILLING --- 7.7 to 10.0 feet
LOGGED BY M Tucker **CHECKED BY** D Lippincott
AT END OF DRILLING ---
NOTES Description from Boring ESTCP-B01
AFTER DRILLING ---

DEPTH (ft)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0.0	SP		(SP) Brown fine SAND, poorly-graded (very well-sorted), loose, dry, homogeneous (top soil).	
2.0		2.0		98.0
2.5	SP		(SP) White fine SAND, poorly-graded (very well-sorted), very loose, dry, homogeneous.	
5.0				
		6.2		93.8
	SP		(SP) Light grayish brown fine SAND, poorly-graded (very well-sorted), loose, moist, homogeneous.	
7.5		7.7		92.3
			NO RECOVERY.	
10.0		10.0		90.0

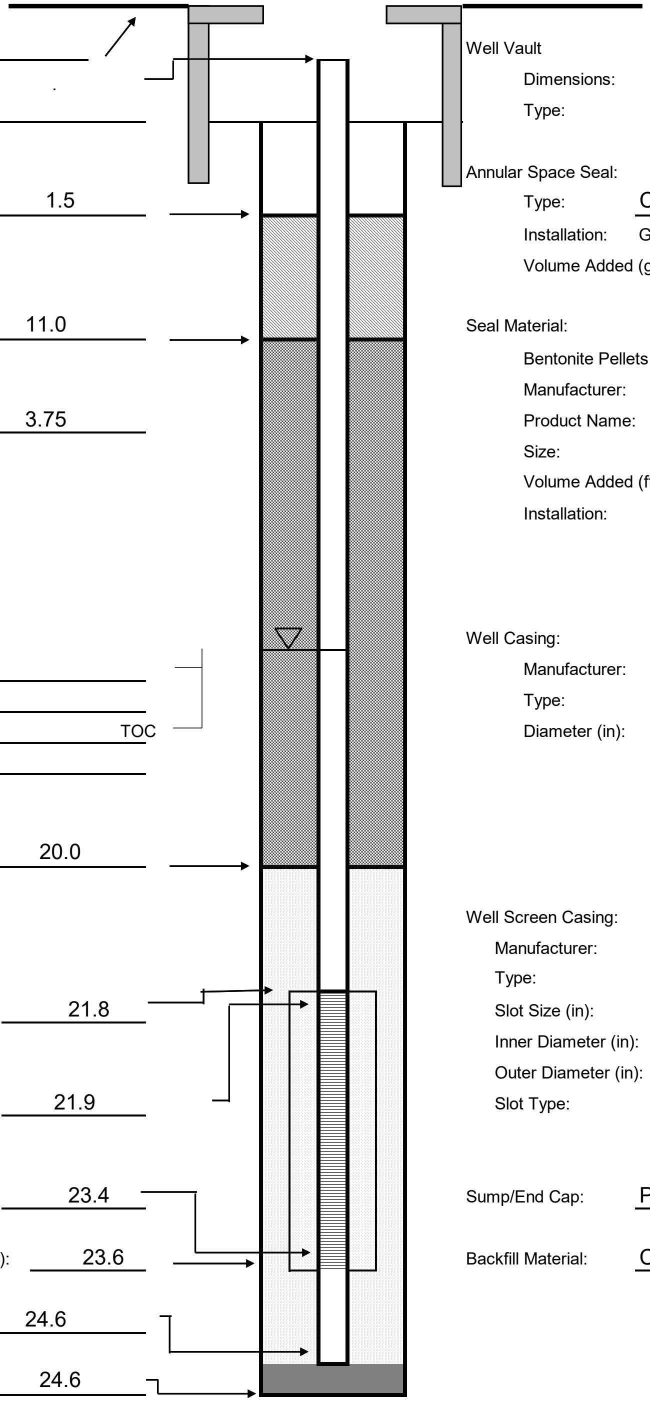
WELL DIAGRAM

Casing Top Elev: 100 (ft)
Casing Type: PVC



Biosparging Well Construction Log

Project:	**Cometabolic Biosparging: Large Dilute Plume**	**Well Number:**	BSW-1S
Location:	**Former Myrtle Beach Airforce Base - South Carolina**	**Site Location:**	**Bldg. 324** OU #
Client:	**ESTCP**	**Installation Date**	6/1/2019
Subcontractor:	**APTIM**	**Northing:**	
Driller:	**Cascade - Charles Terry - License B2080**	**Easting:**	
APTIM Field Representative A. R. Tingle		**Project Number:**	**500814**



Land Surface Elevation (ft msl):

Top of Casing Elevation (ft msl):

Top of Annular Seal (ft bgs): 1.5

Top of Pellet Seal (ft bgs): 11.0

Approximate Diameter of Borehole (in): 3.75

Depth to Water (ft bgs):
During Drilling:
Date:
Post Development:
Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 20.0

Top of Pre-Pack Assembly (ft bgs): 21.8

Top of Screen Interval (ft bgs): 21.9

Bottom of Screen Interval (ft bgs): 23.4

Bottom of Pre-Pack Assembly (ft bgs): 23.6

Bottom of Sump (ft bgs): 24.6

Bottom of Borehole (ft bgs): 24.6

Well Vault
Dimensions: 10-inch by 15-3/8-inch
Type: Fibrelyte Composite

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co. Inc
Product Name: Pel Plug TR 30
Size: 1/4 - inch diameter
Volume Added (ft^3):
Installation: Gravity * Tremie
* through Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1 - inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.01 - inch
Inner Diameter (in): 1 - inch
Outer Diameter (in): 2 - inch
Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot

Backfill Material: Collapse

APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume

Location: Former Myrtle Beach Airforce Base - South Carolina

Client: ESTCP

Subcontractor: APTIM

Driller: Cascade - Charles Terry - License B2080

APTIM Field Representative: A. R. Tingle

Well Number: BSW-2S

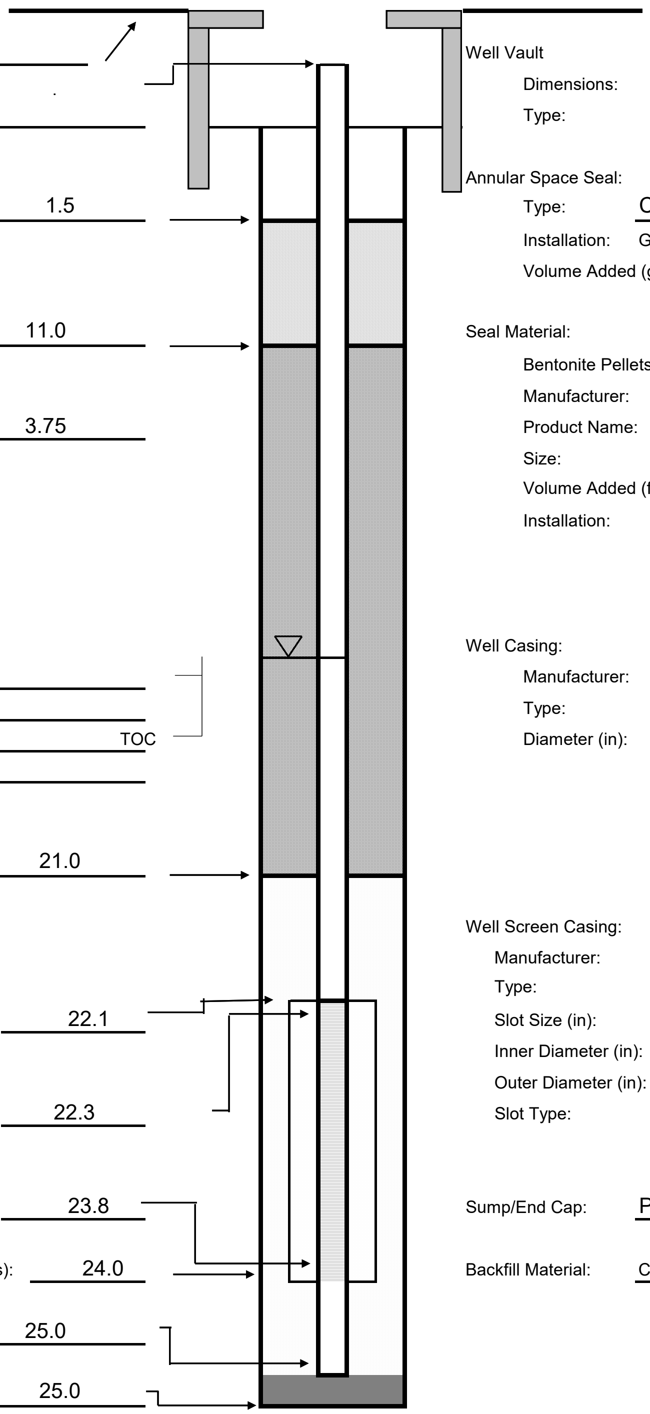
Site Location: Bldg. 324 OU #

Installation Date 6/1/2019

Northing:

Easting:

Project Number: 500814



Land Surface Elevation (ft msl):

Top of Casing Elevation (ft msl):

Top of Annular Seal (ft bgs): 1.5

Top of Pellet Seal (ft bgs): 11.0

Approximate Diameter of Borehole (in): 3.75

Depth to Water (ft bgs):

During Drilling:

Date:

Post Development: TOC

Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 21.0

Top of Pre-Pack Assembly (ft bgs): 22.1

Top of Screen Interval (ft bgs): 22.3

Bottom of Screen Interval (ft bgs): 23.8

Bottom of Pre-Pack Assembly (ft bgs): 24.0

Bottom of Sump (ft bgs): 25.0

Bottom of Borehole (ft bgs): 25.0

Well Vault

Dimensions: 10-inch by 15-3/8-inch

Type: Fibrelyte Composite

Annular Space Seal:

Type: Cement Bentonite Grout

Installation: Gravity Tremie Pumped

Volume Added (gal):

Seal Material:

Bentonite Pellets

Manufacturer: PDS Co. Inc

Product Name: Pel Plug TR 30

Size: 1/4 - inch diameter

Volume Added (ft^3):

Installation: Gravity * Tremie

* through Geoprobe rods

Well Casing:

Manufacturer: Johnson

Type: Schedule 40 PVC

Diameter (in): 1 - inch

Well Screen Casing:

Manufacturer: Johnson

Type: Prepack

Slot Size (in): 0.01 - inch

Inner Diameter (in): 1 - inch

Outer Diameter (in): 2 - inch

Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot

Backfill Material: COLLAPSE

APTIM

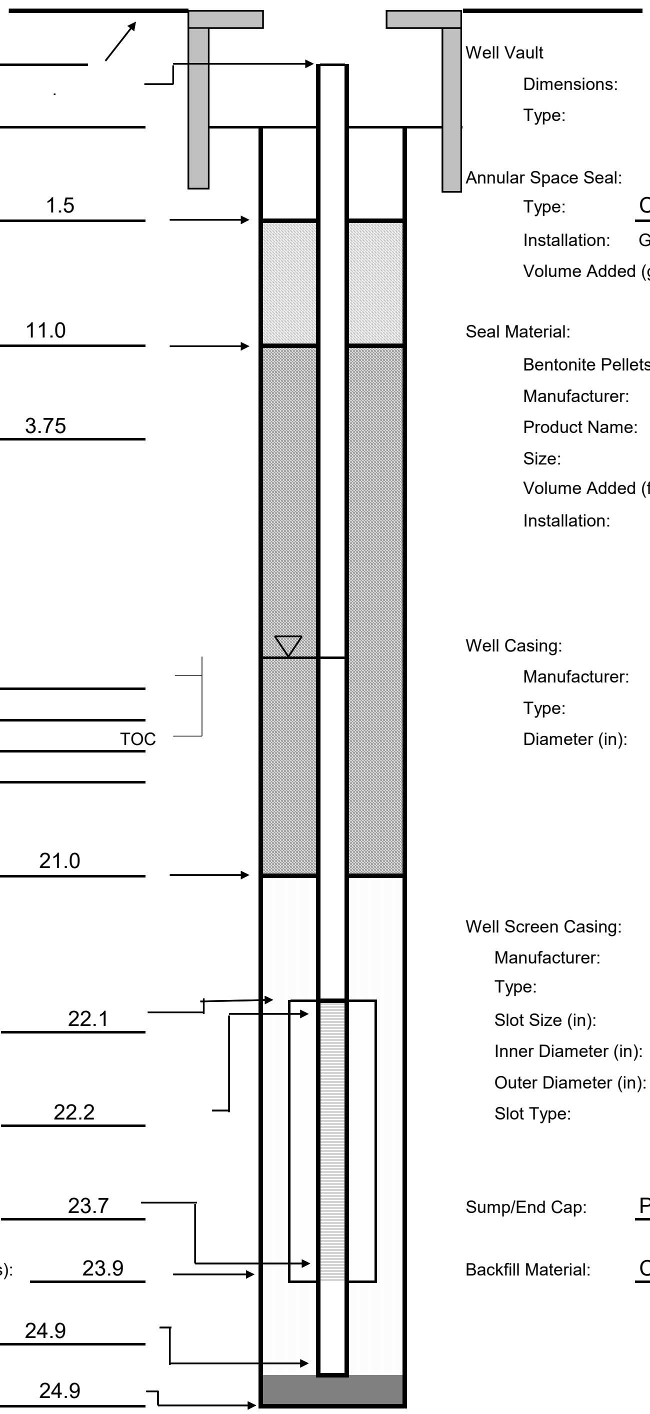
Depths and heights are referenced to ground surface unless specified TOC.

All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Airforce Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: BSW-3S
Site Location: Bldg. 324 OU #
Installation Date 6/2/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 1.5
Top of Pellet Seal (ft bgs): 11.0
Approximate Diameter of Borehole (in): 3.75
Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:
Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 21.0
Top of Pre-Pack Assembly (ft bgs): 22.1
Top of Screen Interval (ft bgs): 22.2
Bottom of Screen Interval (ft bgs): 23.7
Bottom of Pre-Pack Assembly (ft bgs): 23.9
Bottom of Sump (ft bgs): 24.9
Bottom of Borehole (ft bgs): 24.9

Well Vault
Dimensions: 10-inch by 15-3/8-inch
Type: Fibrelyte Composite

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co. Inc
Product Name: Pel Plug TR 30
Size: 1/4 - inch diameter
Volume Added (ft^3):
Installation: Gravity * Tremie
* through Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1 - inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.01 - inch
Inner Diameter (in): 1 - inch
Outer Diameter (in): 2 - inch
Slot Type: Factory slot

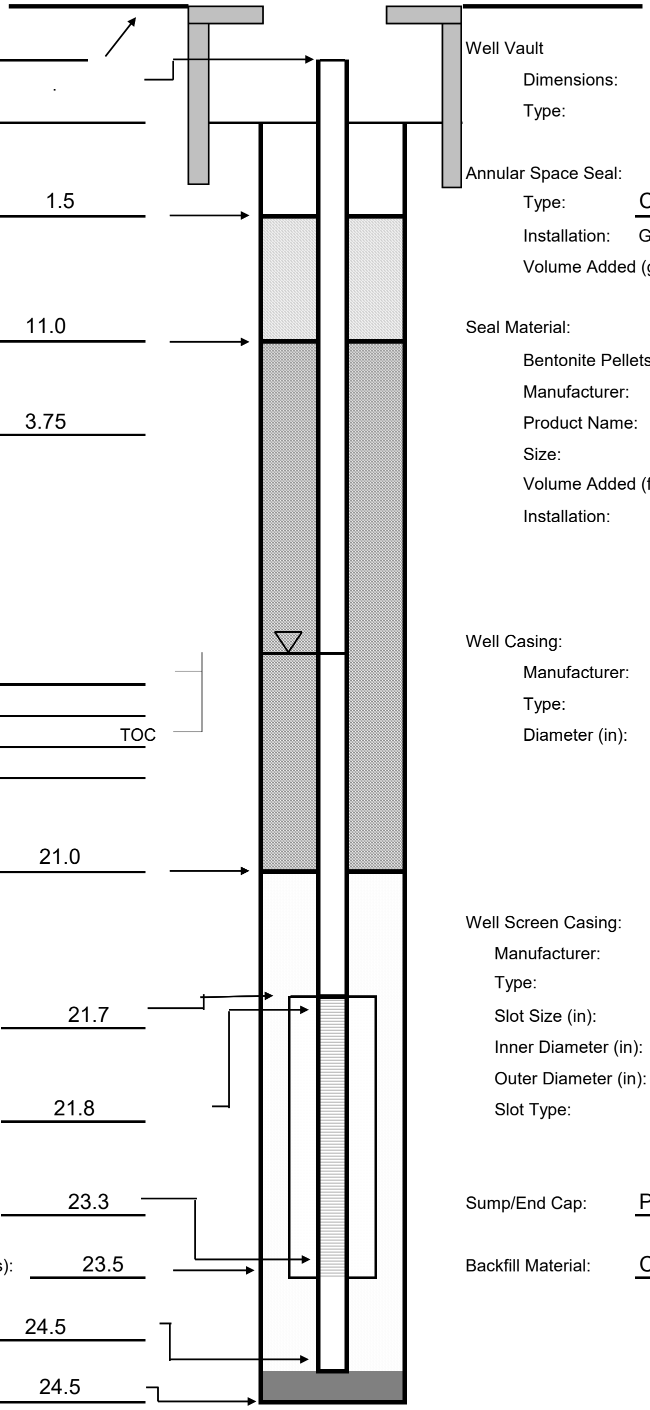
Sump/End Cap: PVC - 1.2 - foot
Backfill Material: Collapse

APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project:	**Cometabolic Biosparging: Large Dilute Plume**	**Well Number:**	BSW-4S
Location:	**Former Myrtle Beach Airforce Base - South Carolina**	**Site Location:**	**Bldg. 324** OU #
Client:	**ESTCP**	**Installation Date**	6/2/2019
Subcontractor:	**APTIM**	**Northing:**	
Driller:	**Cascade - Charles Terry - License B2080**	**Easting:**	
APTIM Field Representative:	**A. R. Tingle**	**Project Number:**	**500814**



Land Surface Elevation (ft msl):

Top of Casing Elevation (ft msl):

Top of Annular Seal (ft bgs): 1.5

Top of Pellet Seal (ft bgs): 11.0

Approximate Diameter of Borehole (in): 3.75

Depth to Water (ft bgs):

During Drilling:

Date:

Post Development:

Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 21.0

Top of Pre-Pack Assembly (ft bgs): 21.7

Top of Screen Interval (ft bgs): 21.8

Bottom of Screen Interval (ft bgs): 23.3

Bottom of Pre-Pack Assembly (ft bgs): 23.5

Bottom of Sump (ft bgs): 24.5

Bottom of Borehole (ft bgs): 24.5

Well Vault

Dimensions: 10-inch by 15-3/8-inch

Type: Fibrelyte Composite

Annular Space Seal:

Type: Cement Bentonite Grout

Installation: Gravity Tremie Pumped

Volume Added (gal):

Seal Material:

Bentonite Pellets

Manufacturer: PDS Co. Inc

Product Name: Pel Plug TR 30

Size: 1/4 - inch diameter

Volume Added (ft^3):

Installation: Gravity * Tremie

* through Geoprobe rods

Well Casing:

Manufacturer: Johnson

Type: Schedule 40 PVC

Diameter (in): 1 - inch

Well Screen Casing:

Manufacturer: Johnson

Type: Prepack

Slot Size (in): 0.01 - inch

Inner Diameter (in): 1 - inch

Outer Diameter (in): 2 - inch

Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot

Backfill Material: Collapse

APTIM

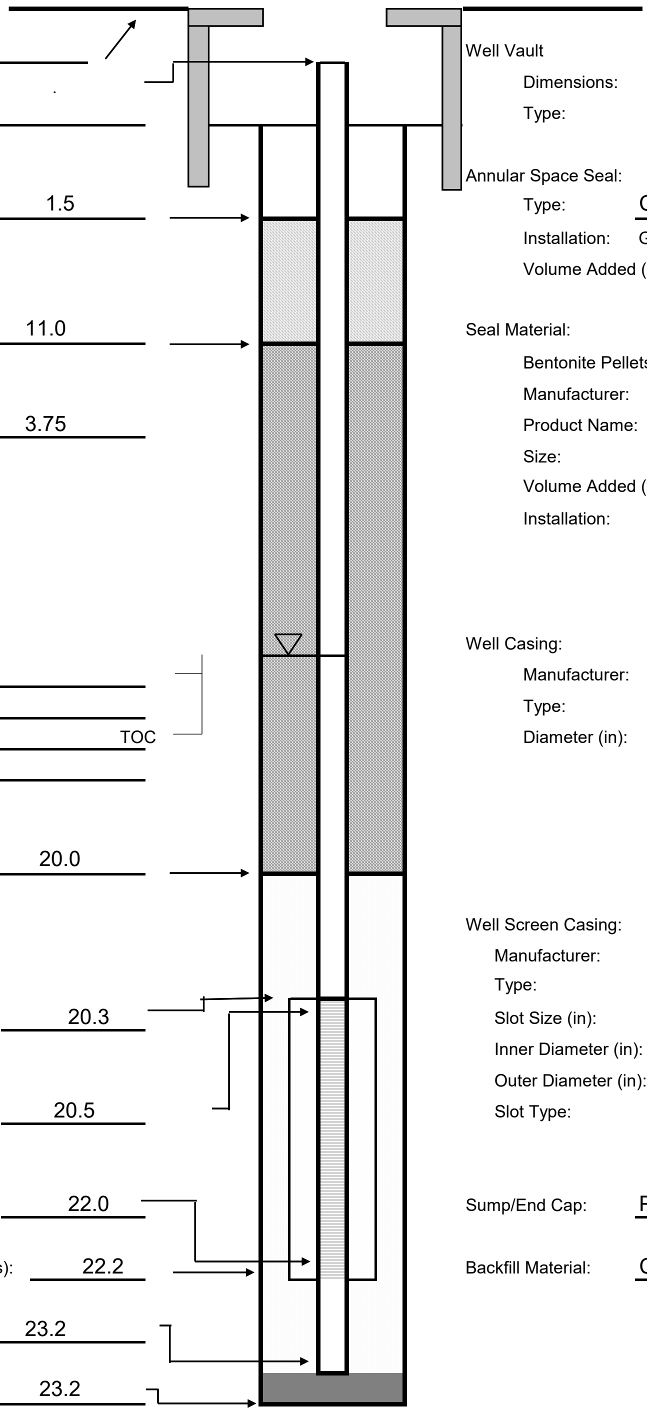
Depths and heights are referenced to ground surface unless specified TOC.

All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Airforce Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: BSW-5S
Site Location: Bldg. 324 OU #
Installation Date 6/4/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 1.5
Top of Pellet Seal (ft bgs): 11.0
Approximate Diameter of Borehole (in): 3.75
Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:
Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 20.0
Top of Pre-Pack Assembly (ft bgs): 20.3
Top of Screen Interval (ft bgs): 20.5
Bottom of Screen Interval (ft bgs): 22.0
Bottom of Pre-Pack Assembly (ft bgs): 22.2
Bottom of Sump (ft bgs): 23.2
Bottom of Borehole (ft bgs): 23.2

Well Vault
Dimensions: 10-inch by 15-3/8-inch
Type: Fibrelyte Composite

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co. Inc
Product Name: Pel Plug TR 30
Size: 1/4 - inch diameter
Volume Added (ft^3):
Installation: Gravity * Tremie
* through Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1 - inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.01 - inch
Inner Diameter (in): 1 - inch
Outer Diameter (in): 2 - inch
Slot Type: Factory slot

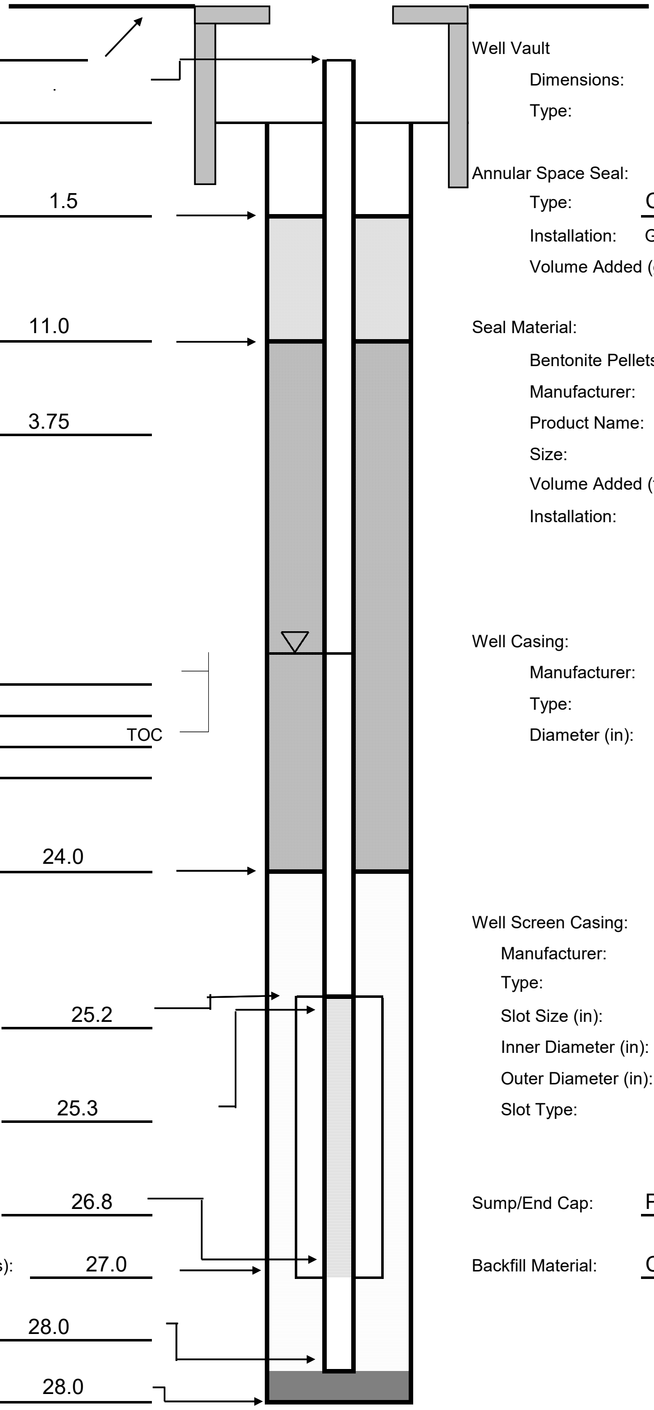
Sump/End Cap: PVC - 1.2 - foot
Backfill Material: Collapse

APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project:	**Cometabolic Biosparging: Large Dilute Plume**	**Well Number:**	BSW-1I
Location:	**Former Myrtle Beach Airforce Base - South Carolina**	**Site Location:**	**Bldg. 324** OU #
Client:	**ESTCP**	**Installation Date**	6/1/2019
Subcontractor:	**APTIM**	**Northing:**	
Driller:	**Cascade - Charles Terry - License B2080**	**Easting:**	
APTIM Field Representative:	**A. R. Tingle**	**Project Number:**	**500814**



Land Surface Elevation (ft msl):

Top of Casing Elevation (ft msl):

Top of Annular Seal (ft bgs): 1.5

Top of Pellet Seal (ft bgs): 11.0

Approximate Diameter of Borehole (in): 3.75

Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 24.0

Top of Pre-Pack Assembly (ft bgs): 25.2

Top of Screen Interval (ft bgs): 25.3

Bottom of Screen Interval (ft bgs): 26.8

Bottom of Pre-Pack Assembly (ft bgs): 27.0

Bottom of Sump (ft bgs): 28.0

Bottom of Borehole (ft bgs): 28.0

Well Vault
Dimensions: 10-inch by 15-3/8-inch
Type: Fibrelyte Composite

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co. Inc
Product Name: Pel Plug TR 30
Size: 1/4 - inch diameter
Volume Added (ft^3):
Installation: Gravity * Tremie
* through Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1 - inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.01 - inch
Inner Diameter (in): 1 - inch
Outer Diameter (in): 2 - inch
Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot

Backfill Material: Collapse

APTIM

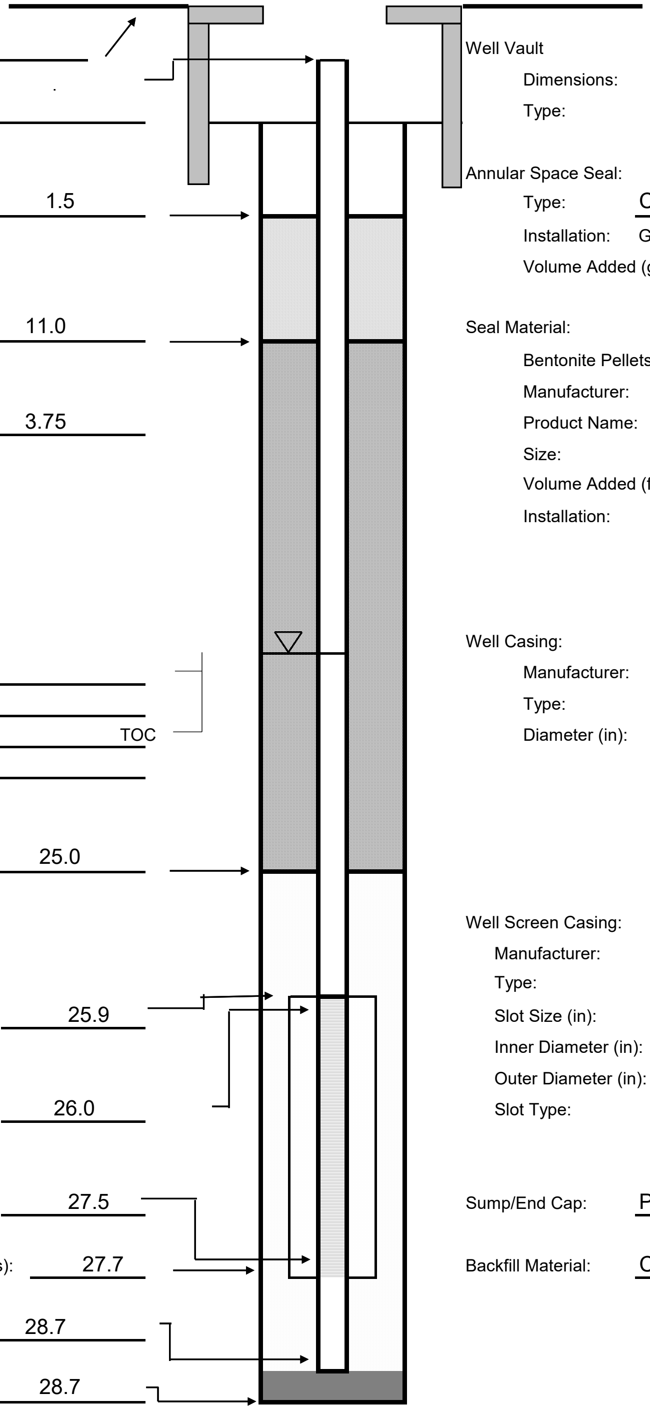
Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project: **Cometabolic Biosparging: Large Dilute Plume**
Location: **Former Myrtle Beach Airforce Base - South Carolina**
Client: **ESTCP**
Subcontractor: **APTIM**
Driller: **Cascade - Charles Terry - License B2080**
APTIM Field Representative: **A. R. Tingle**

Well Number: BSW-2I
Site Location: **Bldg. 324** OU #
Installation Date 6/1/2019
Northing:
Easting:
Project Number: **500814**

Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 1.5
Top of Pellet Seal (ft bgs): 11.0
Approximate Diameter of Borehole (in): 3.75
Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:
Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 25.0
Top of Pre-Pack Assembly (ft bgs): 25.9
Top of Screen Interval (ft bgs): 26.0
Bottom of Screen Interval (ft bgs): 27.5
Bottom of Pre-Pack Assembly (ft bgs): 27.7
Bottom of Sump (ft bgs): 28.7
Bottom of Borehole (ft bgs): 28.7



Well Vault
Dimensions: 10-inch by 15-3/8-inch
Type: Fibrelyte Composite

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co. Inc
Product Name: Pel Plug TR 30
Size: 1/4 - inch diameter
Volume Added (ft^3):
Installation: Gravity * Tremie
* through Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1 - inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.01 - inch
Inner Diameter (in): 1 - inch
Outer Diameter (in): 2 - inch
Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot
Backfill Material: Collapse

APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume

Location: Former Myrtle Beach Airforce Base - South Carolina

Client: ESTCP

Subcontractor: APTIM

Driller: Cascade - Charles Terry - License B2080

APTIM Field Representative: A. R. Tingle

Well Number: BSW-3I

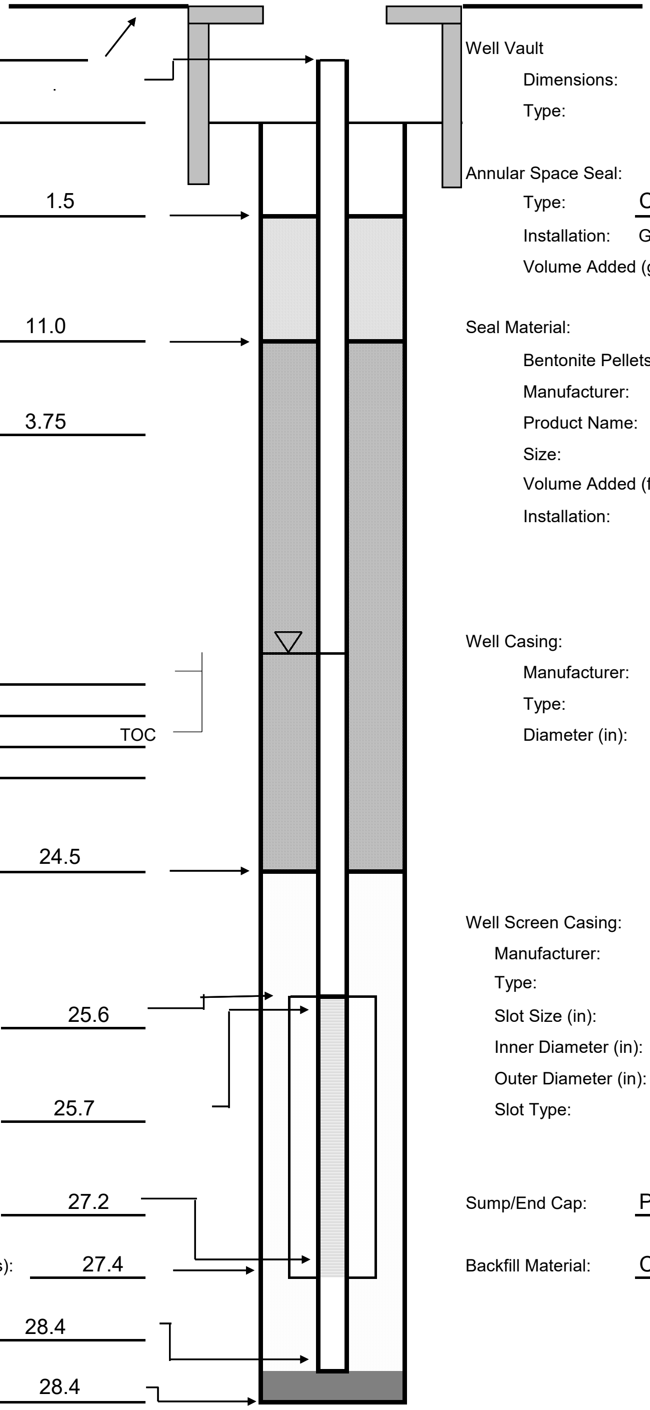
Site Location: Bldg. 324 OU #

Installation Date 6/1/2019

Northing:

Easting:

Project Number: 500814



Land Surface Elevation (ft msl):

Top of Casing Elevation (ft msl):

Top of Annular Seal (ft bgs): 1.5

Top of Pellet Seal (ft bgs): 11.0

Approximate Diameter of Borehole (in): 3.75

Depth to Water (ft bgs):

During Drilling:

Date:

Post Development:

Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 24.5

Top of Pre-Pack Assembly (ft bgs): 25.6

Top of Screen Interval (ft bgs): 25.7

Bottom of Screen Interval (ft bgs): 27.2

Bottom of Pre-Pack Assembly (ft bgs): 27.4

Bottom of Sump (ft bgs): 28.4

Bottom of Borehole (ft bgs): 28.4

Well Vault

Dimensions: 10-inch by 15-3/8-inch

Type: Fibrelyte Composite

Annular Space Seal:

Type: Cement Bentonite Grout

Installation: Gravity Tremie Pumped

Volume Added (gal):

Seal Material:

Bentonite Pellets

Manufacturer: PDS Co. Inc

Product Name: Pel Plug TR 30

Size: 1/4 - inch diameter

Volume Added (ft^3):

Installation: Gravity * Tremie

* through Geoprobe rods

Well Casing:

Manufacturer: Johnson

Type: Schedule 40 PVC

Diameter (in): 1 - inch

Well Screen Casing:

Manufacturer: Johnson

Type: Prepack

Slot Size (in): 0.01 - inch

Inner Diameter (in): 1 - inch

Outer Diameter (in): 2 - inch

Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot

Backfill Material: Collapse

APTIM

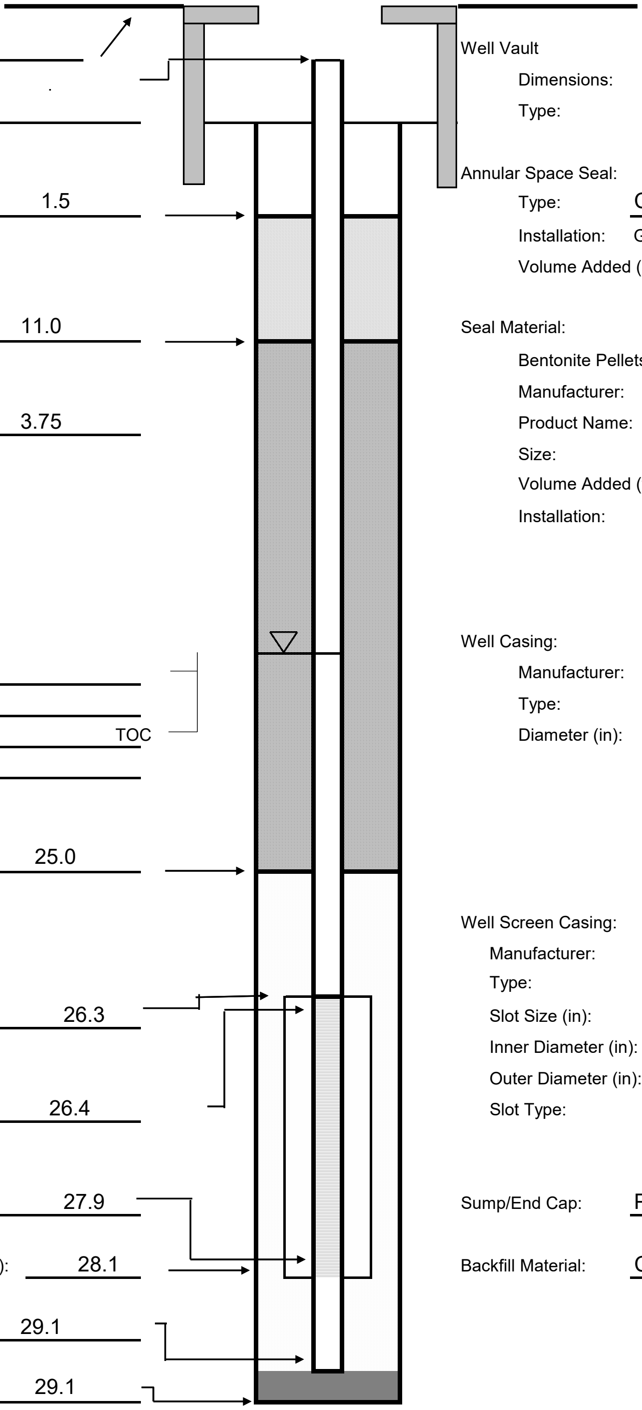
Depths and heights are referenced to ground surface unless specified TOC.

All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Airforce Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: BSW-4I
Site Location: Bldg. 324 OU #
Installation Date 6/2/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 1.5
Top of Pellet Seal (ft bgs): 11.0
Approximate Diameter of Borehole (in): 3.75
Depth to Water (ft bgs):
During Drilling:
Date:
Post Development:
Date:
Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 25.0
Top of Pre-Pack Assembly (ft bgs): 26.3
Top of Screen Interval (ft bgs): 26.4
Bottom of Screen Interval (ft bgs): 27.9
Bottom of Pre-Pack Assembly (ft bgs): 28.1
Bottom of Sump (ft bgs): 29.1
Bottom of Borehole (ft bgs): 29.1

Well Vault
Dimensions: 10-inch by 15-3/8-inch
Type: Fibrelyte Composite

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co. Inc
Product Name: Pel Plug TR 30
Size: 1/4 - inch diameter
Volume Added (ft^3):
Installation: Gravity * Tremie
* through Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1 - inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.01 - inch
Inner Diameter (in): 1 - inch
Outer Diameter (in): 2 - inch
Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot
Backfill Material: Collapse

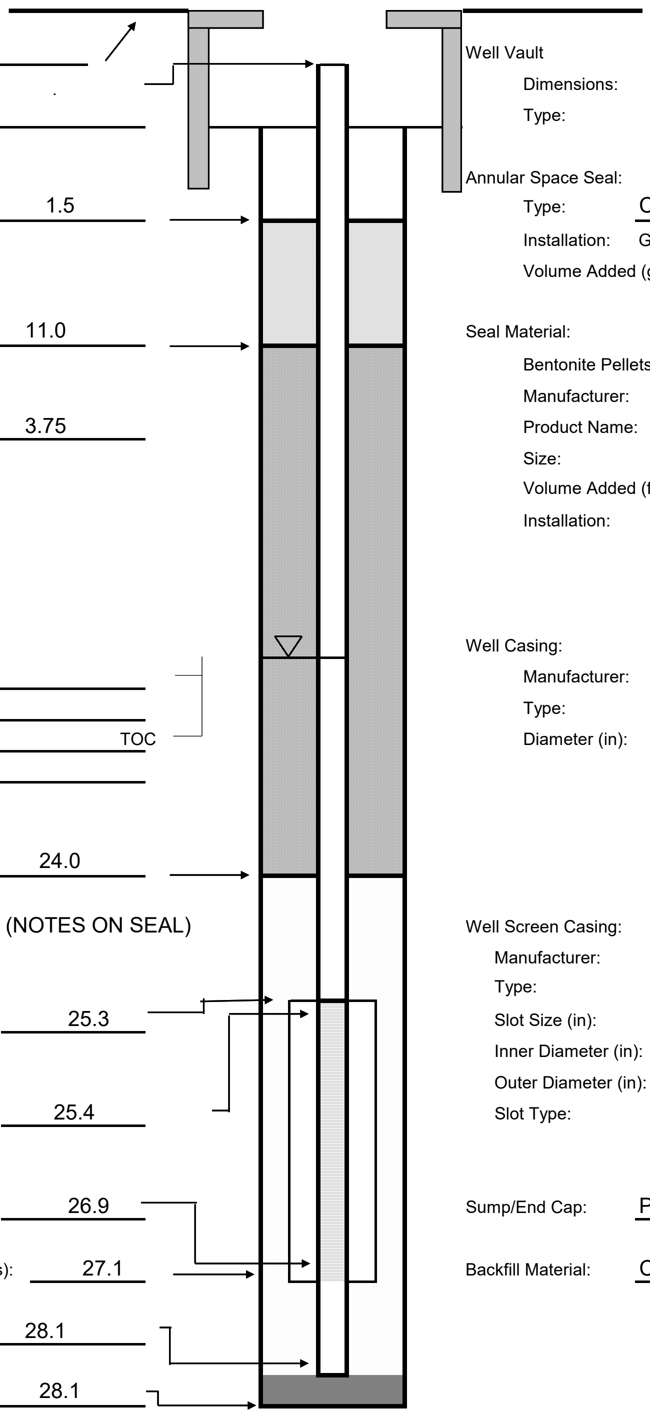
APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Airforce Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: BSW-5I
Site Location: Bldg. 324 OU #
Installation Date 6/2/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 1.5
Top of Pellet Seal (ft bgs): 11.0
Approximate Diameter of Borehole (in): 3.75

Depth to Water (ft bgs):
During Drilling:
Date:
Post Development:
Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 24.0

19 - 24 = PELLET SEAL
14 - 19 = COLLAPSE (NOTES ON SEAL)
11 - 14 PELLET SEAL

Top of Pre-Pack Assembly (ft bgs): 25.3
Top of Screen Interval (ft bgs): 25.4
Bottom of Screen Interval (ft bgs): 26.9
Bottom of Pre-Pack Assembly (ft bgs): 27.1
Bottom of Sump (ft bgs): 28.1
Bottom of Borehole (ft bgs): 28.1

Well Vault
Dimensions: 10-inch by 15-3/8-inch
Type: Fibrelyte Composite

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co. Inc
Product Name: Pel Plug TR 30
Size: 1/4 - inch diameter
Volume Added (ft^3):
Installation: Gravity * Tremie
* through Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1 - inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.01 - inch
Inner Diameter (in): 1 - inch
Outer Diameter (in): 2 - inch
Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot
Backfill Material: Collapse

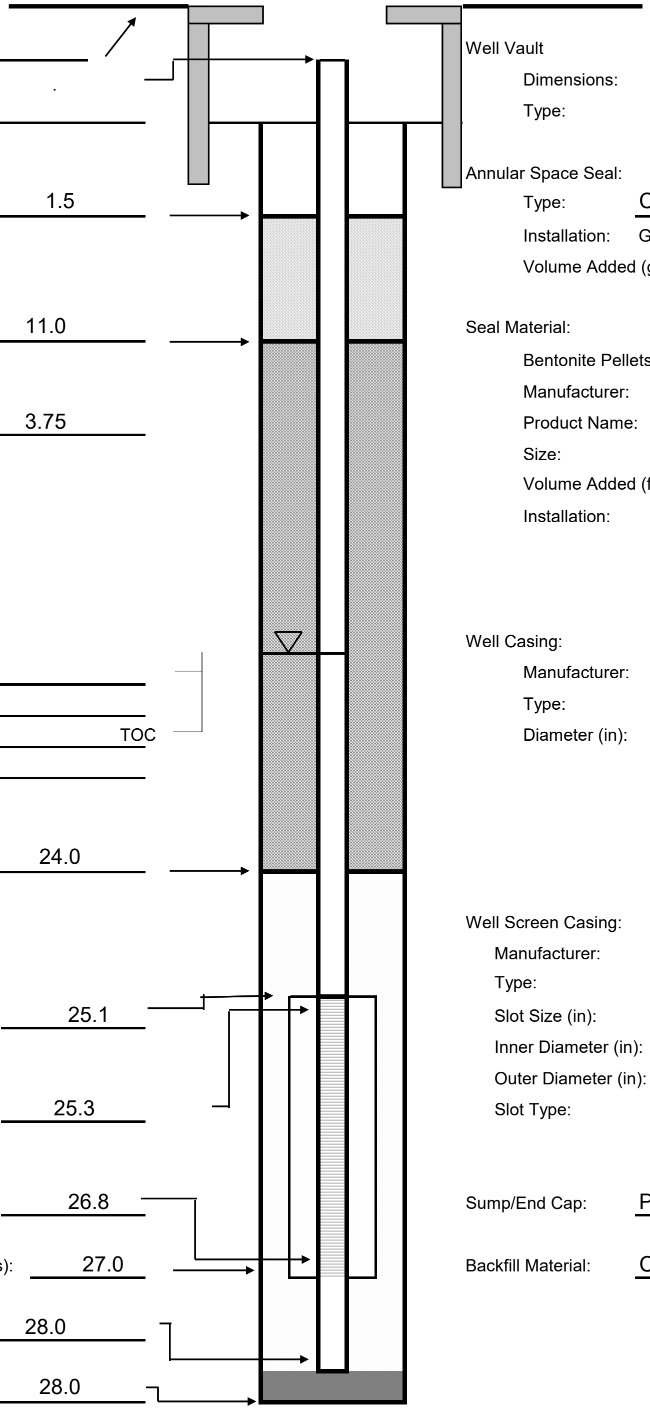
APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project: **Cometabolic Biosparging: Large Dilute Plume**
Location: **Former Myrtle Beach Airforce Base - South Carolina**
Client: **ESTCP**
Subcontractor: **APTIM**
Driller: **Cascade - Charles Terry - License B2080**
APTIM Field Representative: **A. R. Tingle**

Well Number: BSW-6I
Site Location: **Bldg. 324** OU #
Installation Date 6/4/2019
Northing:
Easting:
Project Number: **500814**



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 1.5
Top of Pellet Seal (ft bgs): 11.0
Approximate Diameter of Borehole (in): 3.75
Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:
Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 24.0
Top of Pre-Pack Assembly (ft bgs): 25.1
Top of Screen Interval (ft bgs): 25.3
Bottom of Screen Interval (ft bgs): 26.8
Bottom of Pre-Pack Assembly (ft bgs): 27.0
Bottom of Sump (ft bgs): 28.0
Bottom of Borehole (ft bgs): 28.0

Well Vault
Dimensions: 10-inch by 15-3/8-inch
Type: Fibrelyte Composite

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co. Inc
Product Name: Pel Plug TR 30
Size: 1/4 - inch diameter
Volume Added (ft^3):
Installation: Gravity * Tremie
* through Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1 - inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.01 - inch
Inner Diameter (in): 1 - inch
Outer Diameter (in): 2 - inch
Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot

Backfill Material: Collapse

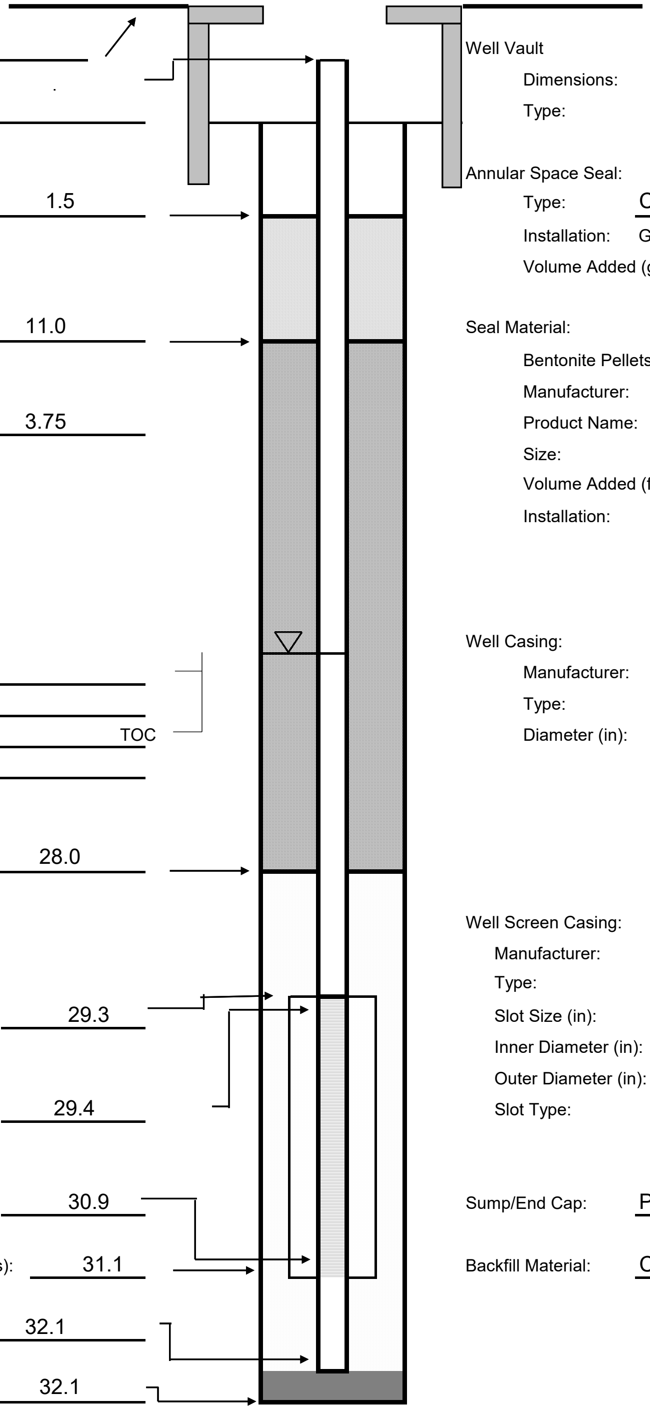
APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Airforce Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: BSW-1D
Site Location: Bldg. 324 OU #
Installation Date 6/1/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 1.5
Top of Pellet Seal (ft bgs): 11.0
Approximate Diameter of Borehole (in): 3.75

Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 28.0
Top of Pre-Pack Assembly (ft bgs): 29.3
Top of Screen Interval (ft bgs): 29.4
Bottom of Screen Interval (ft bgs): 30.9
Bottom of Pre-Pack Assembly (ft bgs): 31.1
Bottom of Sump (ft bgs): 32.1
Bottom of Borehole (ft bgs): 32.1

Well Vault
Dimensions: 10-inch by 15-3/8-inch
Type: Fibrelyte Composite

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co. Inc
Product Name: Pel Plug TR 30
Size: 1/4 - inch diameter
Volume Added (ft^3):
Installation: Gravity * Tremie
* through Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1 - inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.01 - inch
Inner Diameter (in): 1 - inch
Outer Diameter (in): 2 - inch
Slot Type: Factory slot

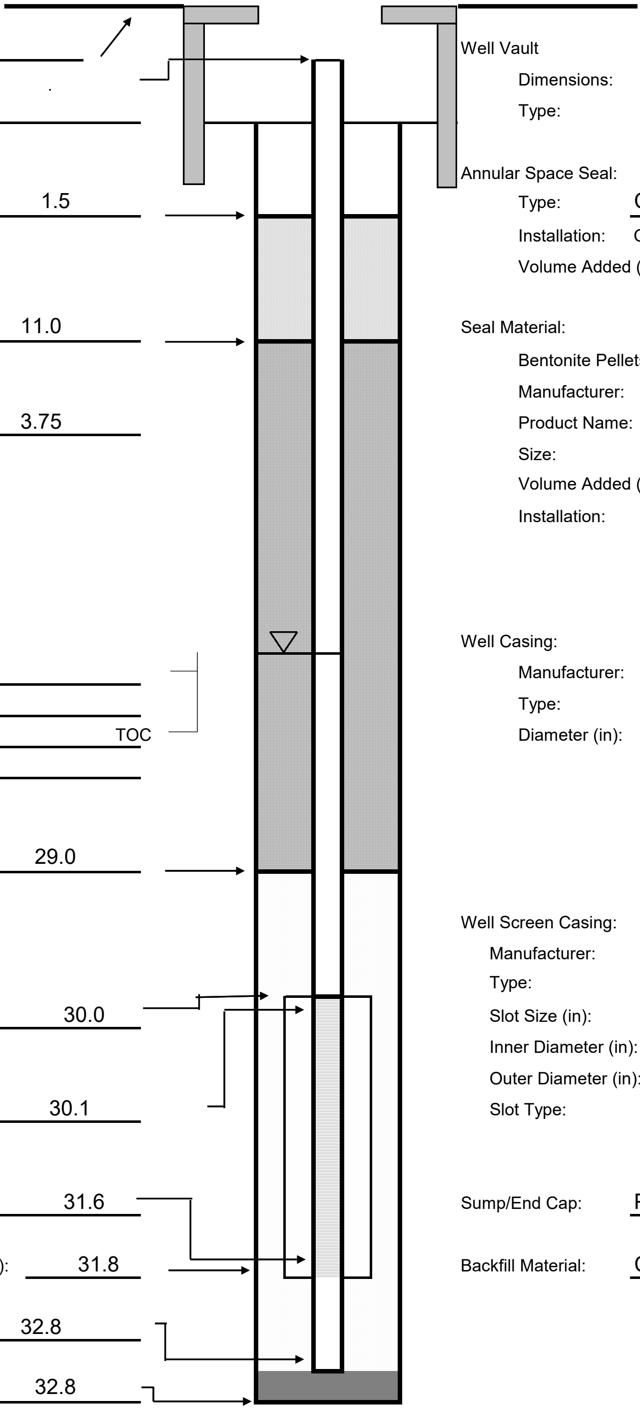
Sump/End Cap: PVC - 1.2 - foot
Backfill Material: Collapse

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Airforce Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: BSW-02D
Site Location: Bldg. 324 OU #
Installation Date 6/1/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):

Top of Casing Elevation (ft msl):

Top of Annular Seal (ft bgs): 1.5

Top of Pellet Seal (ft bgs): 11.0

Approximate Diameter of Borehole (in): 3.75

Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 29.0

Top of Pre-Pack Assembly (ft bgs): 30.0

Top of Screen Interval (ft bgs): 30.1

Bottom of Screen Interval (ft bgs): 31.6

Bottom of Pre-Pack Assembly (ft bgs): 31.8

Bottom of Sump (ft bgs): 32.8

Bottom of Borehole (ft bgs): 32.8

Well Vault
Dimensions: 10-inch by 15-3/8-inch
Type: Fibrelyte Composite

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co. Inc
Product Name: Pel Plug TR 30
Size: 1/4 - inch diameter
Volume Added (ft^3):
Installation: Gravity * Tremie
* through Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1 - inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.01 - inch
Inner Diameter (in): 1 - inch
Outer Diameter (in): 2 - inch
Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot

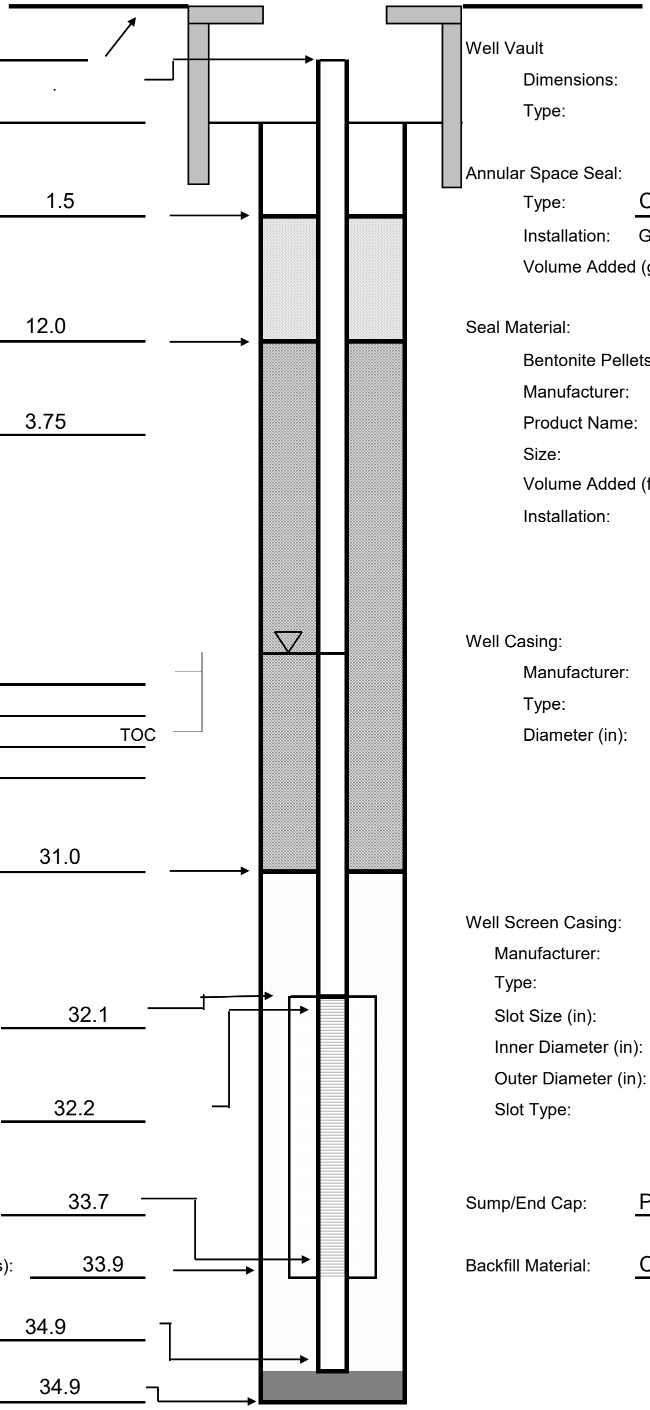
Backfill Material: Collapse

APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project:	**Cometabolic Biosparging: Large Dilute Plume**	**Well Number:**	BSW-03D
Location:	**Former Myrtle Beach Airforce Base - South Carolina**	**Site Location:**	**Bldg. 324** OU #
Client:	**ESTCP**	**Installation Date**	5/31/2019
Subcontractor:	**APTIM**	**Northing:**	
Driller:	**Cascade - Charles Terry - License B2080**	**Easting:**	
APTIM Field Representative:	**A. R. Tingle**	**Project Number:**	**500814**



Land Surface Elevation (ft msl):

Top of Casing Elevation (ft msl):

Top of Annular Seal (ft bgs): 1.5

Top of Pellet Seal (ft bgs): 12.0

Approximate Diameter of Borehole (in): 3.75

Depth to Water (ft bgs):

During Drilling:

Date:

Post Development:

Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 31.0

Top of Pre-Pack Assembly (ft bgs): 32.1

Top of Screen Interval (ft bgs): 32.2

Bottom of Screen Interval (ft bgs): 33.7

Bottom of Pre-Pack Assembly (ft bgs): 33.9

Bottom of Sump (ft bgs): 34.9

Bottom of Borehole (ft bgs): 34.9

Well Vault

Dimensions: 10-inch by 15-3/8-inch

Type: Fibrelyte Composite

Annular Space Seal:

Type: Cement Bentonite Grout

Installation: Gravity Tremie Pumped

Volume Added (gal):

Seal Material:

Bentonite Pellets

Manufacturer: PDS Co. Inc

Product Name: Pel Plug TR 30

Size: 1/4 - inch diameter

Volume Added (ft^3):

Installation: Gravity * Tremie

* through Geoprobe rods

Well Casing:

Manufacturer: Johnson

Type: Schedule 40 PVC

Diameter (in): 1 - inch

Well Screen Casing:

Manufacturer: Johnson

Type: Prepack

Slot Size (in): 0.01 - inch

Inner Diameter (in): 1 - inch

Outer Diameter (in): 2 - inch

Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot

Backfill Material: Collapse

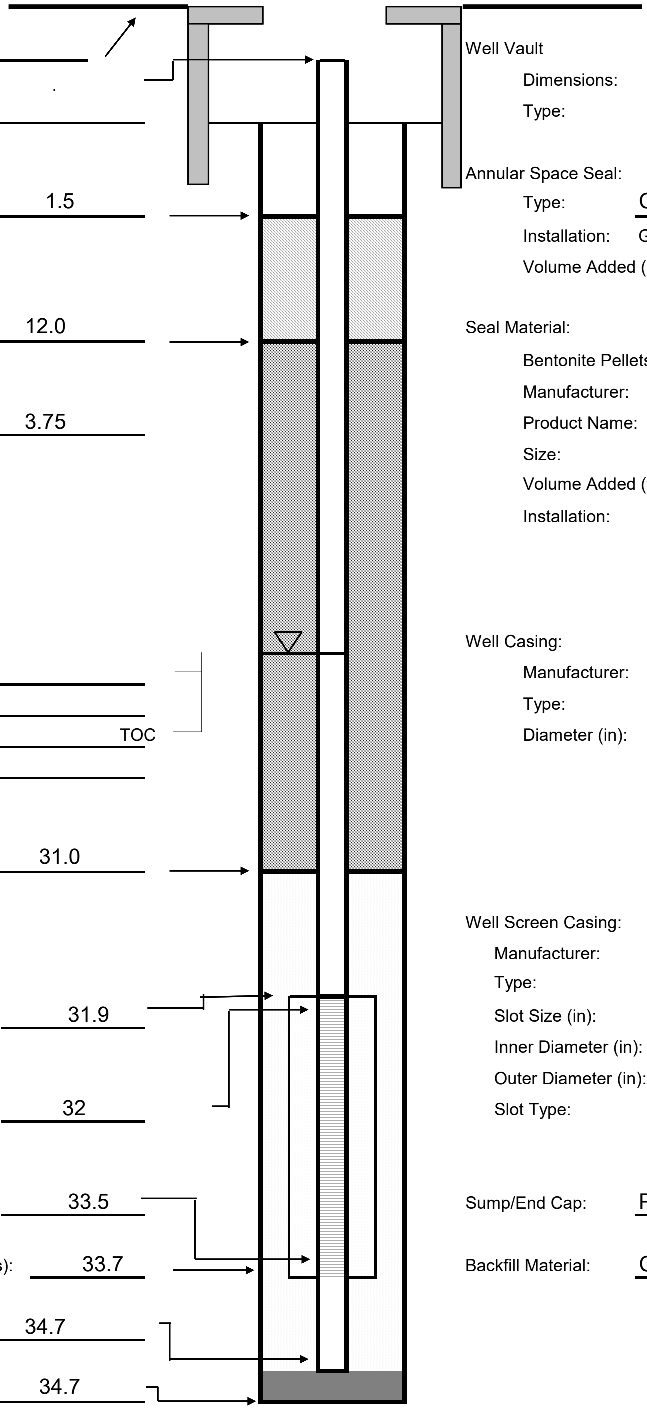
APTIM

Depths and heights are referenced to ground surface unless specified TOC.

All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project:	**Cometabolic Biosparging: Large Dilute Plume**	**Well Number:**	BSW-04D
Location:	**Former Myrtle Beach Airforce Base - South Carolina**	**Site Location:**	**Bldg. 324** OU #
Client:	**ESTCP**	**Installation Date**	5/31/2019
Subcontractor:	**APTIM**	**Northing:**	
Driller:	**Cascade - Charles Terry - License B2080**	**Easting:**	
APTIM Field Representative:	**A. R. Tingle**	**Project Number:**	**500814**



Land Surface Elevation (ft msl):

Top of Casing Elevation (ft msl):

Top of Annular Seal (ft bgs): 1.5

Top of Pellet Seal (ft bgs): 12.0

Approximate Diameter of Borehole (in): 3.75

Depth to Water (ft bgs):

During Drilling:

Date:

Post Development: TOC

Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 31.0

Top of Pre-Pack Assembly (ft bgs): 31.9

Top of Screen Interval (ft bgs): 32

Bottom of Screen Interval (ft bgs): 33.5

Bottom of Pre-Pack Assembly (ft bgs): 33.7

Bottom of Sump (ft bgs): 34.7

Bottom of Borehole (ft bgs): 34.7

Well Vault

Dimensions: 10-inch by 15-3/8-inch

Type: Fibrelyte Composite

Annular Space Seal:

Type: Cement Bentonite Grout

Installation: Gravity Tremie Pumped

Volume Added (gal):

Seal Material:

Bentonite Pellets

Manufacturer: PDS Co. Inc

Product Name: Pel Plug TR 30

Size: 1/4 - inch diameter

Volume Added (ft^3):

Installation: Gravity * Tremie

* through Geoprobe rods

Well Casing:

Manufacturer: Johnson

Type: Schedule 40 PVC

Diameter (in): 1 - inch

Well Screen Casing:

Manufacturer: Johnson

Type: Prepack

Slot Size (in): 0.01 - inch

Inner Diameter (in): 1 - inch

Outer Diameter (in): 2 - inch

Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot

Backfill Material: Collapse

APTIM

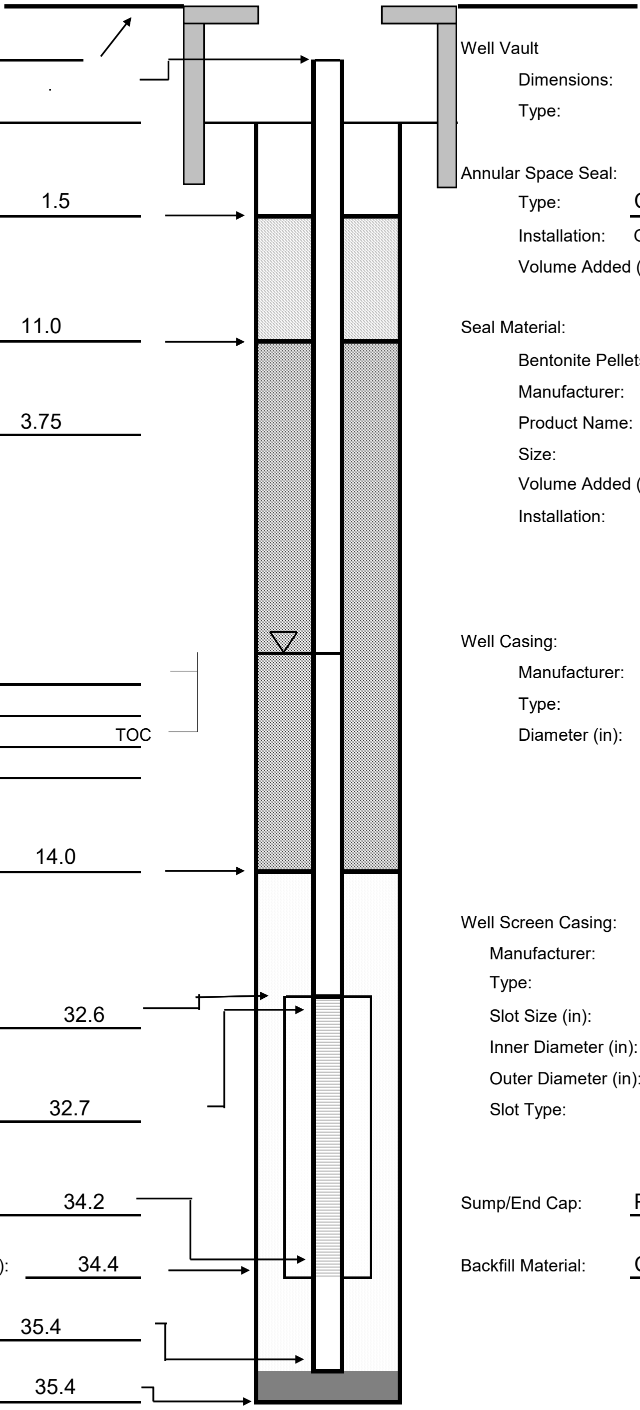
Depths and heights are referenced to ground surface unless specified TOC.

All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Airforce Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: SW-05D
Site Location: Bldg. 324 OU #
Installation Date 5/31/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 1.5
Top of Pellet Seal (ft bgs): 11.0
Approximate Diameter of Borehole (in): 3.75
Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:
Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 14.0
Top of Pre-Pack Assembly (ft bgs): 32.6
Top of Screen Interval (ft bgs): 32.7
Bottom of Screen Interval (ft bgs): 34.2
Bottom of Pre-Pack Assembly (ft bgs): 34.4
Bottom of Sump (ft bgs): 35.4
Bottom of Borehole (ft bgs): 35.4

Well Vault
Dimensions: 10-inch by 15-3/8-inch
Type: Fibrelyte Composite

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co. Inc
Product Name: Pel Plug TR 30
Size: 1/4 - inch diameter
Volume Added (ft^3):
Installation: Gravity * Tremie
* through Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1 - inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.01 - inch
Inner Diameter (in): 1 - inch
Outer Diameter (in): 2 - inch
Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot
Backfill Material: Collapse

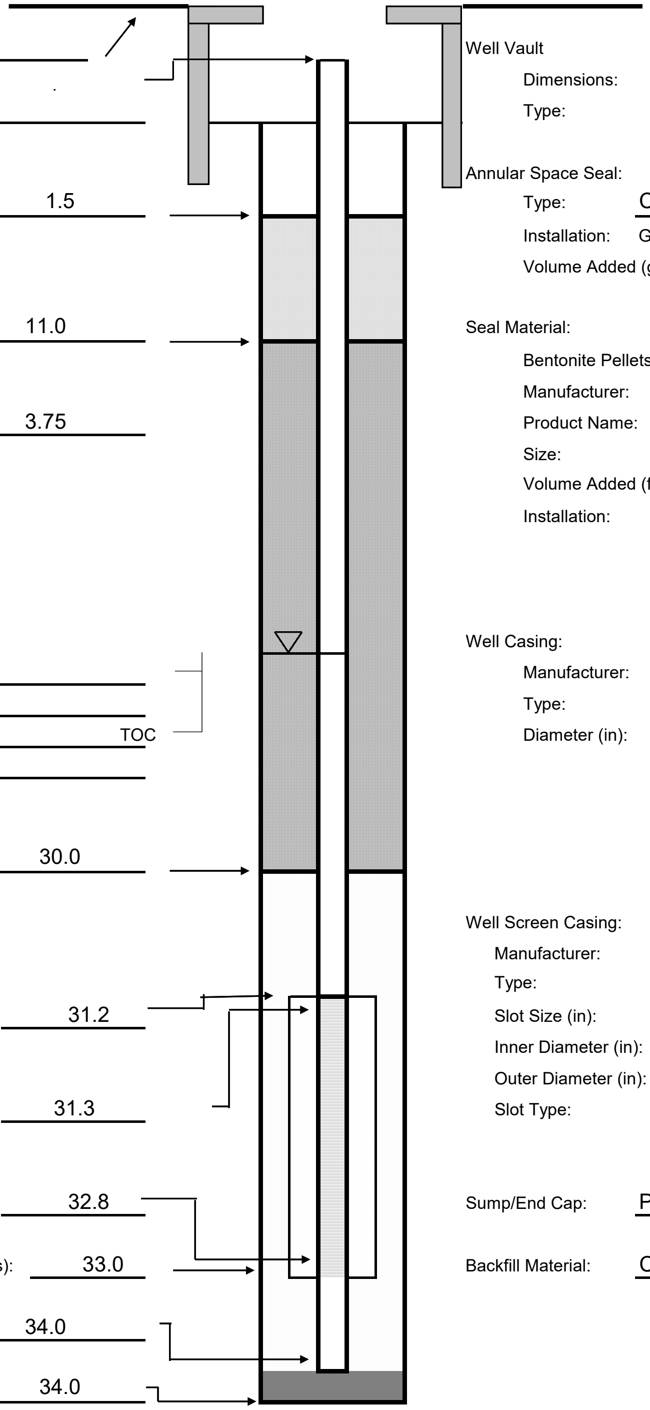
APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Airforce Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: BSW-06D
Site Location: Bldg. 324 OU #
Installation Date 5/31/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 1.5
Top of Pellet Seal (ft bgs): 11.0
Approximate Diameter of Borehole (in): 3.75
Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:
Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 30.0
Top of Pre-Pack Assembly (ft bgs): 31.2
Top of Screen Interval (ft bgs): 31.3
Bottom of Screen Interval (ft bgs): 32.8
Bottom of Pre-Pack Assembly (ft bgs): 33.0
Bottom of Sump (ft bgs): 34.0
Bottom of Borehole (ft bgs): 34.0

Well Vault
Dimensions: 10-inch by 15-3/8-inch
Type: Fibrelyte Composite

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co. Inc
Product Name: Pel Plug TR 30
Size: 1/4 - inch diameter
Volume Added (ft^3):
Installation: Gravity * Tremie
* through Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1 - inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.01 - inch
Inner Diameter (in): 1 - inch
Outer Diameter (in): 2 - inch
Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot
Backfill Material: Collapse

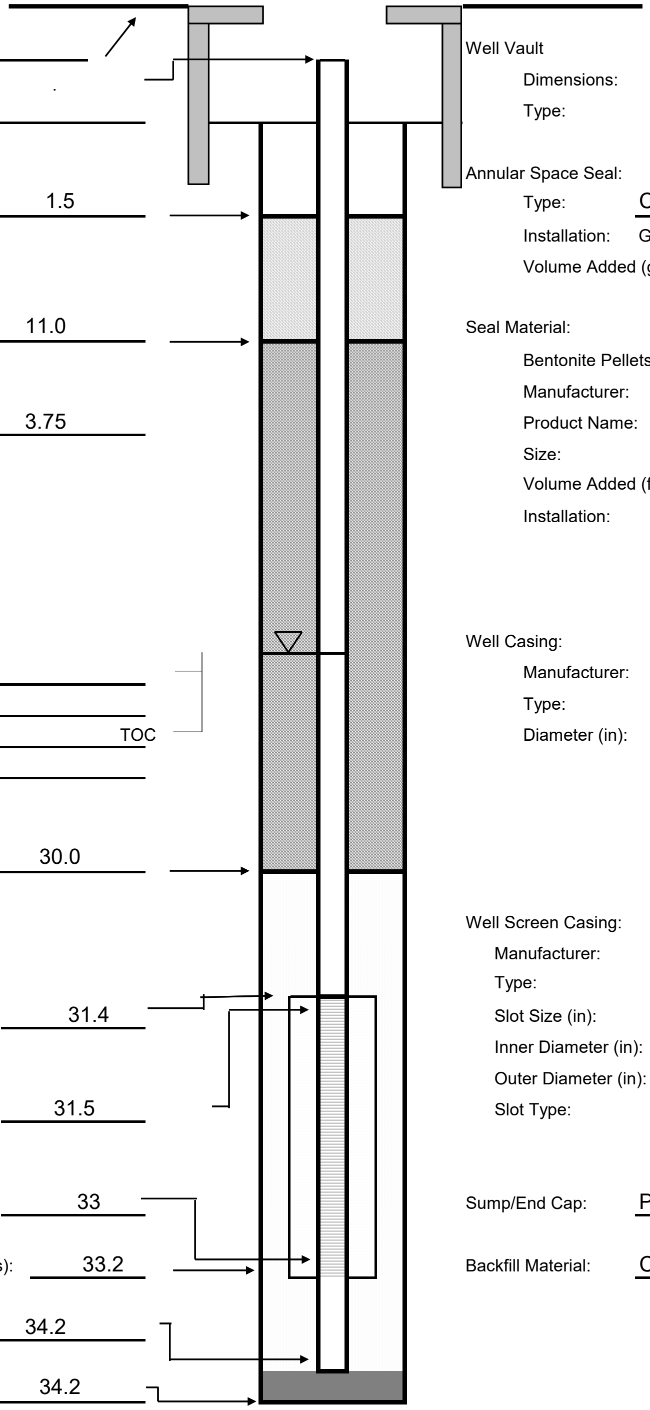
APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Airforce Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: BSW-07D
Site Location: Bldg. 324 OU #
Installation Date 5/31/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 1.5
Top of Pellet Seal (ft bgs): 11.0
Approximate Diameter of Borehole (in): 3.75

Depth to Water (ft bgs):
During Drilling:
Date:
Post Development:
Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 30.0
Top of Pre-Pack Assembly (ft bgs): 31.4
Top of Screen Interval (ft bgs): 31.5
Bottom of Screen Interval (ft bgs): 33
Bottom of Pre-Pack Assembly (ft bgs): 33.2
Bottom of Sump (ft bgs): 34.2
Bottom of Borehole (ft bgs): 34.2

Well Vault
Dimensions: 10-inch by 15-3/8-inch
Type: Fibrelyte Composite

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co. Inc
Product Name: Pel Plug TR 30
Size: 1/4 - inch diameter
Volume Added (ft^3):
Installation: Gravity * Tremie
* through Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1 - inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.01 - inch
Inner Diameter (in): 1 - inch
Outer Diameter (in): 2 - inch
Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot
Backfill Material: Collapse

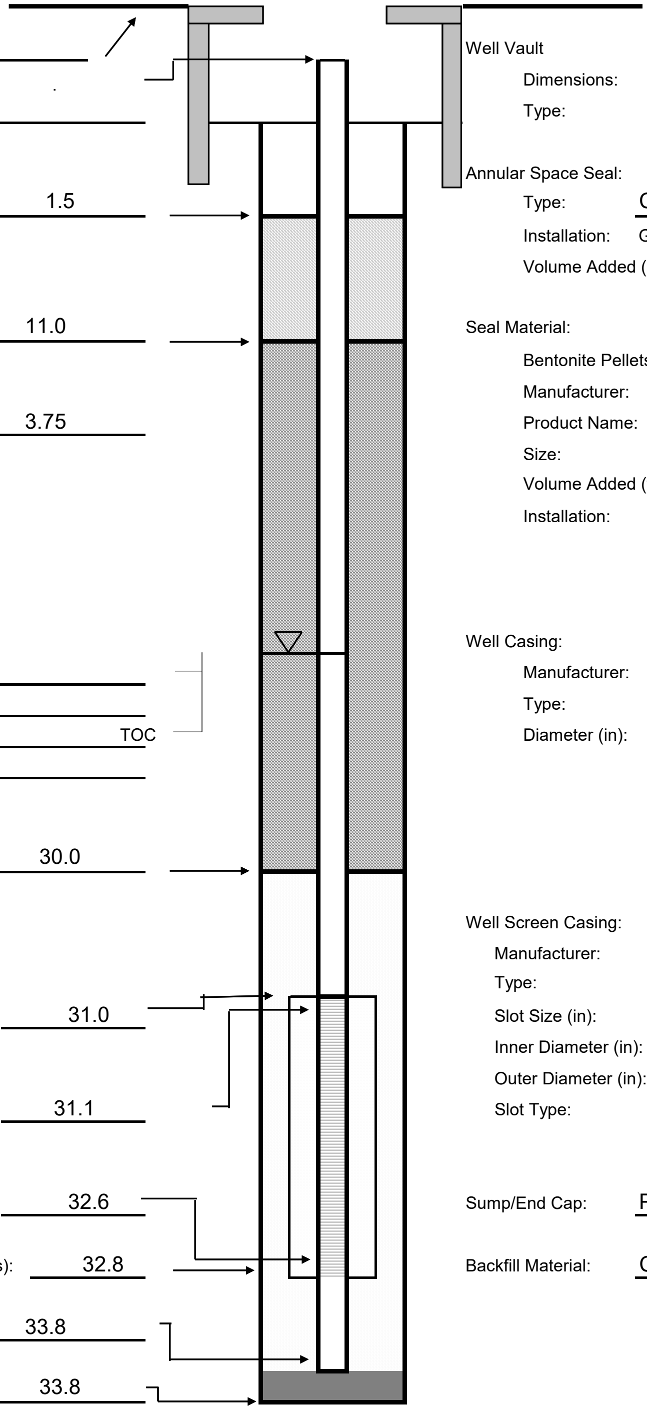
APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Airforce Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: BSW-08D
Site Location: Bldg. 324 OU #
Installation Date 5/31/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 1.5
Top of Pellet Seal (ft bgs): 11.0
Approximate Diameter of Borehole (in): 3.75
Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:
Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 30.0
Top of Pre-Pack Assembly (ft bgs): 31.0
Top of Screen Interval (ft bgs): 31.1
Bottom of Screen Interval (ft bgs): 32.6
Bottom of Pre-Pack Assembly (ft bgs): 32.8
Bottom of Sump (ft bgs): 33.8
Bottom of Borehole (ft bgs): 33.8

Well Vault
Dimensions: 10-inch by 15-3/8-inch
Type: Fibrelyte Composite

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co. Inc
Product Name: Pel Plug TR 30
Size: 1/4 - inch diameter
Volume Added (ft^3):
Installation: Gravity * Tremie
* through Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1 - inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.01 - inch
Inner Diameter (in): 1 - inch
Outer Diameter (in): 2 - inch
Slot Type: Factory slot

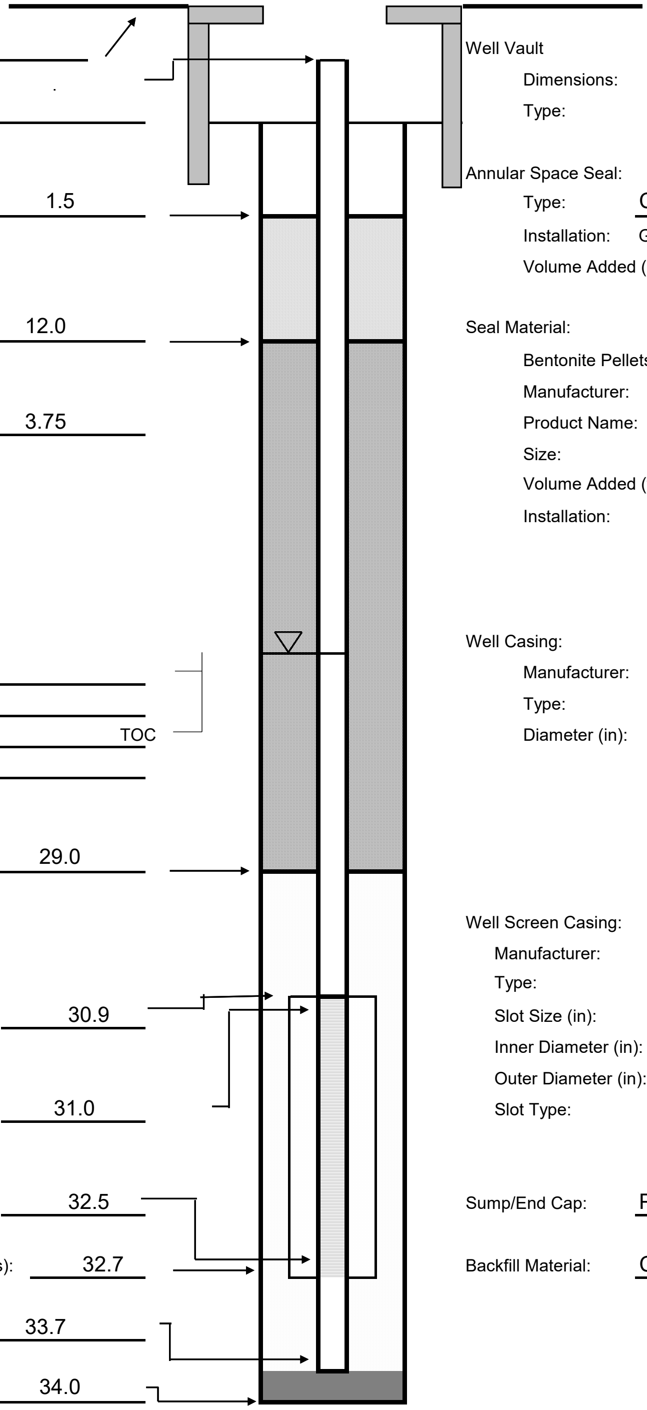
Sump/End Cap: PVC - 1.2 - foot
Backfill Material: Collapse

APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project:	**Cometabolic Biosparging: Large Dilute Plume**	**Well Number:**	BSW-09D
Location:	**Former Myrtle Beach Airforce Base - South Carolina**	**Site Location:**	**Bldg. 324** OU #
Client:	**ESTCP**	**Installation Date**	5/30/2019
Subcontractor:	**APTIM**	**Northing:**	
Driller:	**Cascade - Charles Terry - License B2080**	**Easting:**	
APTIM Field Representative:	**A. R. Tingle**	**Project Number:**	**500814**



Land Surface Elevation (ft msl):

Top of Casing Elevation (ft msl):

Top of Annular Seal (ft bgs): 1.5

Top of Pellet Seal (ft bgs): 12.0

Approximate Diameter of Borehole (in): 3.75

Depth to Water (ft bgs):

During Drilling:

Date:

Post Development:

Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 29.0

Top of Pre-Pack Assembly (ft bgs): 30.9

Top of Screen Interval (ft bgs): 31.0

Bottom of Screen Interval (ft bgs): 32.5

Bottom of Pre-Pack Assembly (ft bgs): 32.7

Bottom of Sump (ft bgs): 33.7

Bottom of Borehole (ft bgs): 34.0

Well Vault

Dimensions: 10-inch by 15-3/8-inch

Type: Fibrelyte Composite

Annular Space Seal:

Type: Cement Bentonite Grout

Installation: Gravity Tremie Pumped

Volume Added (gal):

Seal Material:

Bentonite Pellets

Manufacturer: PDS Co. Inc

Product Name: Pel Plug TR 30

Size: 1/4 - inch diameter

Volume Added (ft^3):

Installation: Gravity * Tremie

* through Geoprobe rods

Well Casing:

Manufacturer: Johnson

Type: Schedule 40 PVC

Diameter (in): 1 - inch

Well Screen Casing:

Manufacturer: Johnson

Type: Prepack

Slot Size (in): 0.01 - inch

Inner Diameter (in): 1 - inch

Outer Diameter (in): 2 - inch

Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot

Backfill Material: Collapse

APTIM

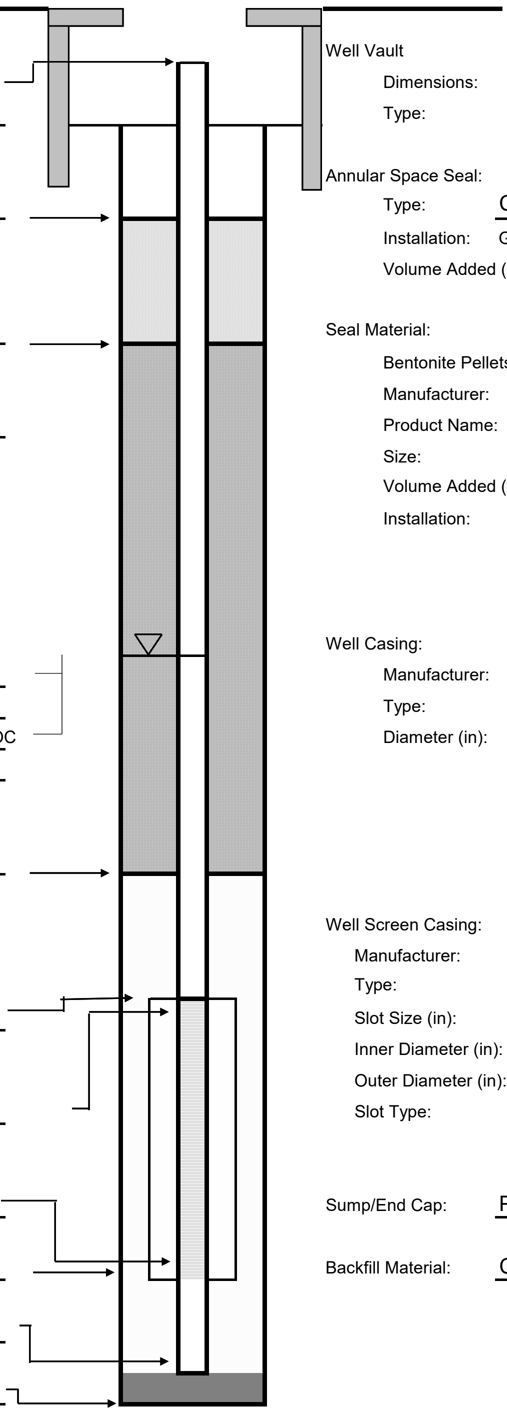
Depths and heights are referenced to ground surface unless specified TOC.

All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Airforce Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: BSW-10D
Site Location: Bldg. 324 OU #
Installation Date 5/30/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 1.5
Top of Pellet Seal (ft bgs): 11.0
Approximate Diameter of Borehole (in): 3.75
Depth to Water (ft bgs):
During Drilling:
Date:
Post Development:
Date:
Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 30.0
Top of Pre-Pack Assembly (ft bgs): 31.4
Top of Screen Interval (ft bgs): 31.5
Bottom of Screen Interval (ft bgs): 33.0
Bottom of Pre-Pack Assembly (ft bgs): 33.2
Bottom of Sump (ft bgs): 34.2
Bottom of Borehole (ft bgs): 34.2

Well Vault
Dimensions: 10-inch by 15-3/8-inch
Type: Fibrelyte Composite

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co. Inc
Product Name: Pel Plug TR 30
Size: 1/4 - inch diameter
Volume Added (ft^3):
Installation: Gravity * Tremie
* through Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1 - inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.01 - inch
Inner Diameter (in): 1 - inch
Outer Diameter (in): 2 - inch
Slot Type: Factory slot

Sump/End Cap: PVC - 1.2 - foot
Backfill Material: Collapse

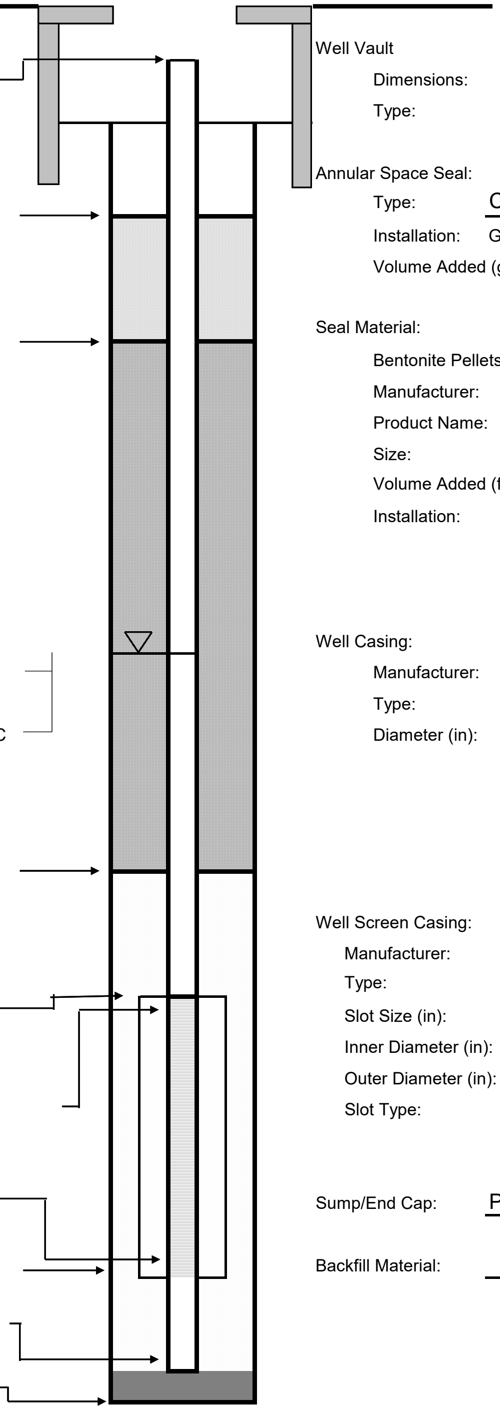
APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Biosparging Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Airforce Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: BSW-11D
Site Location: Bldg. 324 OU #
Installation Date 5/19/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 1.5
Top of Pellet Seal (ft bgs): 11.0
Approximate Diameter of Borehole (in): 3.75
Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:
Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 30.0
Top of Pre-Pack Assembly (ft bgs): 31.2
Top of Screen Interval (ft bgs): 31.3
Bottom of Screen Interval (ft bgs): 32.8
Bottom of Pre-Pack Assembly (ft bgs): 33.0
Bottom of Sump (ft bgs): 34.0
Bottom of Borehole (ft bgs): 34.3

Well Vault
Dimensions: 10-inch by 15-3/8-inch
Type: Fibrelyte Composite

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co. Inc
Product Name: Pel Plug TR 30
Size: 1/4 - inch diameter
Volume Added (ft^3):
Installation: Gravity * Tremie
* through Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1 - inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.01 - inch
Inner Diameter (in): 1 - inch
Outer Diameter (in): 2 - inch
Slot Type: Factory slot

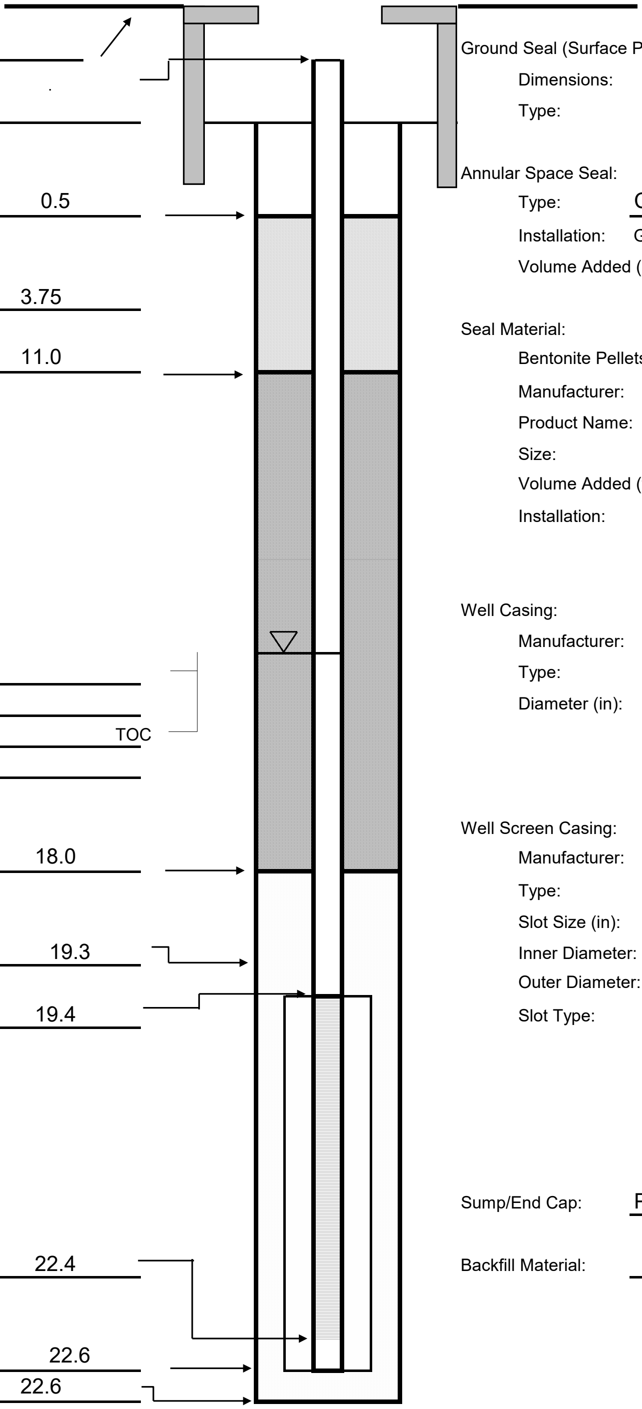
Sump/End Cap: PVC - 1.2 - foot
Backfill Material:

APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Monitoring Well Construction Log

Project:	**Cometabolic Biosparging: Large Dilute Plume**	**Well Number:**	PMW-1S
Location:	**Former Myrtle Beach Air Force Base - South Carolina**	**Site Location:**	**Bldg 324** OU #
Client:	**ESTCP**	**Installation Date**	**6/3/2019**
Subcontractor:	**APTIM**	**Northing:**	
Driller:	**Cascade - Charles Terry - License B2080**	**Easting:**	
APTIM Field Representative:	**A. R. Tingle**	**Project Number:**	**500814**



Land Surface Elevation (ft msl):

Top of Casing Elevation (ft msl):

Top of Annular Seal (ft bgs): 0.5

Approximate Diameter of Borehole (in): 3.75

Top of Pellet Seal (ft bgs): 11.0

Depth to Water (ft bgs):

During Drilling:

Date:

Post Development: TOC

Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 18.0

Top of Pre-Pack Assembly (ft bgs): 19.3

Top of Screen Interval (ft bgs): 19.4

Bottom of Screen Interval (ft): 22.4

Bottom of Pre-Pack Assembly (ft): 22.6

Bottom of Borehole (ft): 22.6

Ground Seal (Surface Pad)

Dimensions: 18-inch x 18-inch x 4-inch

Type: Concrete

Annular Space Seal:

Type: Cement Bentonite Grout

Installation: Gravity Tremie Pumped

Volume Added (gal):

Seal Material:

Bentonite Pellets

Manufacturer: PDS Co Inc.

Product Name: Pel-Plug TR30

Size: 1/4 inch diameter

Volume Added (ft^3):

Installation: Gravity* Tremie

* throgh the Geoprobe rods

Well Casing:

Manufacturer: Johnson

Type: Schedule 40 PVC

Diameter (in): 1.25 inch

Well Screen Casing:

Manufacturer: Johnson

Type: Prepack

Slot Size (in): 0.010

Inner Diameter: 1.25"

Outer Diameter: 2.8"

Slot Type: Factory slot

Sump/End Cap: PVC - 0.2-foot

Backfill Material:

APTIM

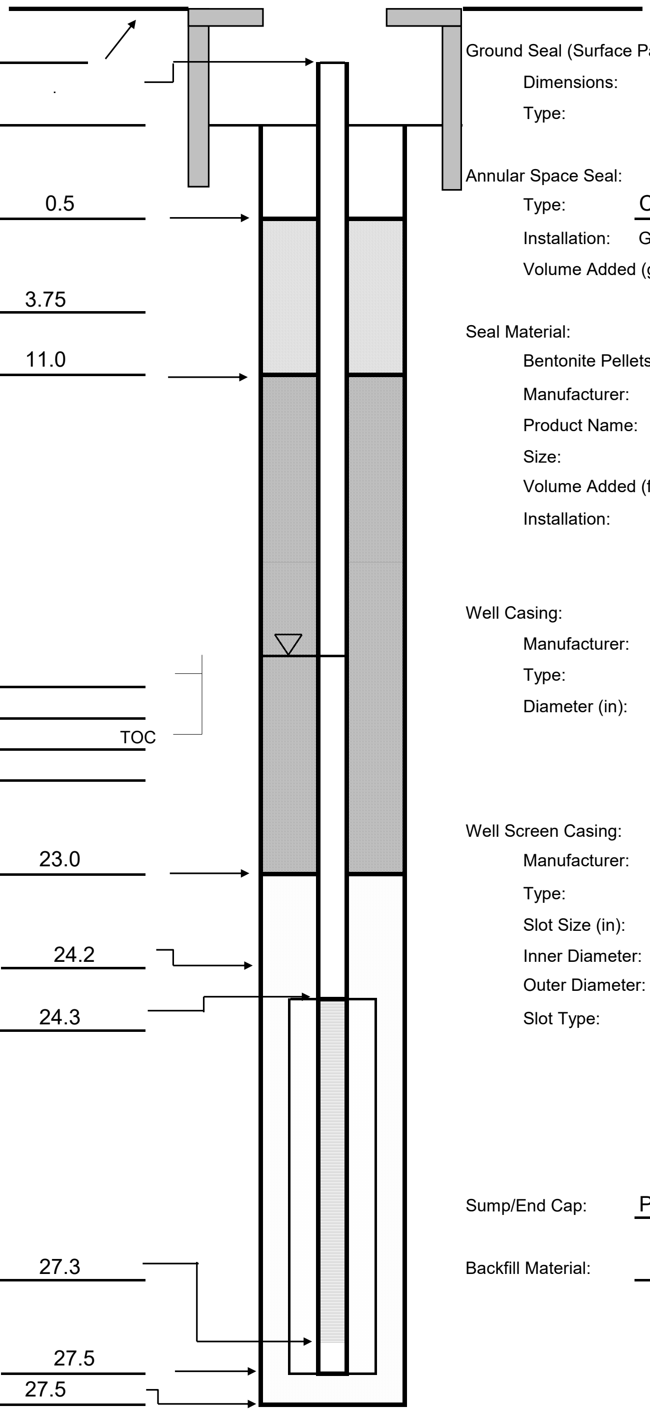
Depths and heights are referenced to ground surface unless specified TOC.

All elevations are referenced to MSL (NAVD 88).

Monitoring Well Construction Log

Project: **Cometabolic Biosparging: Large Dilute Plume**
Location: **Former Myrtle Beach Air Force Base - South Carolina**
Client: **ESTCP**
Subcontractor: **APTIM**
Driller: **Cascade - Charles Terry - License B2080**
APTIM Field Representative: **A. R. Tingle**

Well Number: PMW-1I
Site Location: **Bldg 324** OU #
Installation Date **6/3/2019**
Northing:
Easting:
Project Number: **500814**



Land Surface Elevation (ft msl):

Top of Casing Elevation (ft msl):

Top of Annular Seal (ft bgs): 0.5

Approximate Diameter of Borehole (in): 3.75

Top of Pellet Seal (ft bgs): 11.0

Depth to Water (ft bgs):
During Drilling:
Date:
Post Development:
Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 23.0

Top of Pre-Pack Assembly (ft bgs): 24.2

Top of Screen Interval (ft bgs): 24.3

Bottom of Screen Interval (ft): 27.3

Bottom of Pre-Pack Assembly (ft): 27.5

Bottom of Borehole (ft): 27.5

Ground Seal (Surface Pad)
Dimensions: 18-inch x 18-inch x 4-inch
Type: Concrete

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co Inc.
Product Name: Pel-Plug TR30
Size: 1/4 inch diameter
Volume Added (ft^3):
Installation: Gravity* Tremie
* throgh the Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1.25 inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.010
Inner Diameter: 1.25"
Outer Diameter: 2.8"
Slot Type: Factory slot

Sump/End Cap: PVC - 0.2-foot

Backfill Material:

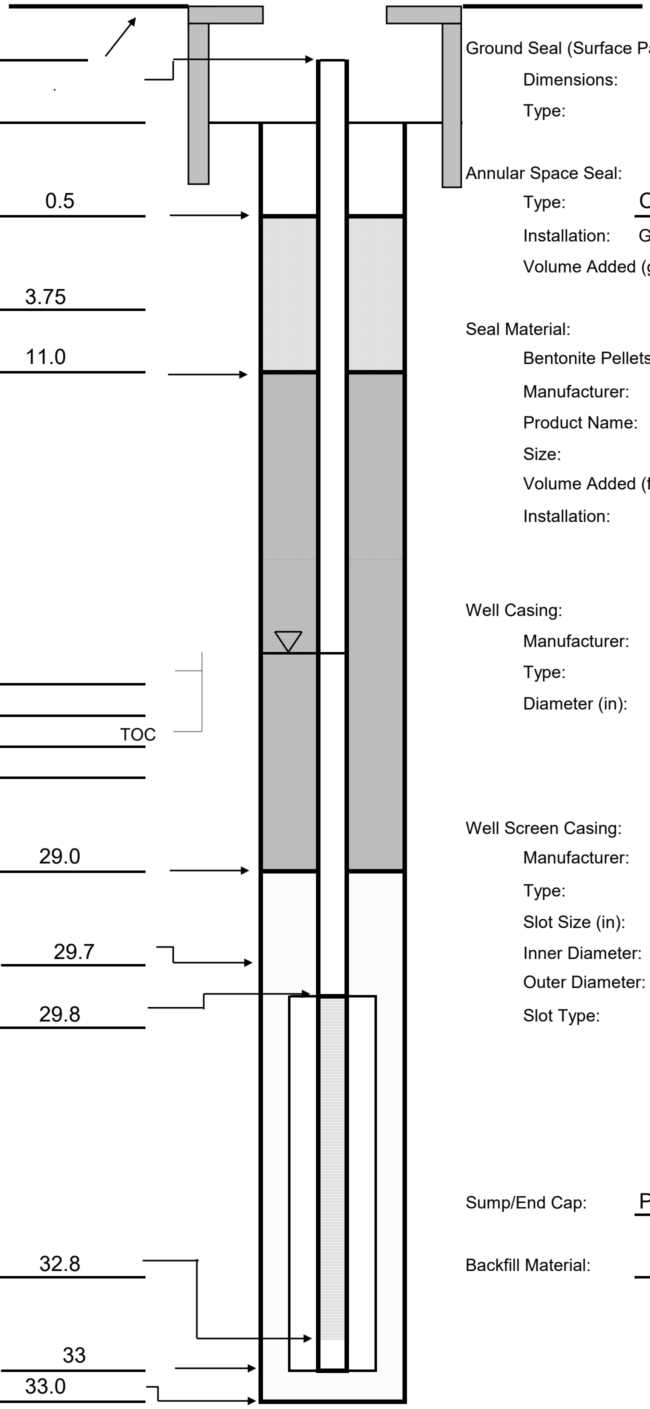
APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Monitoring Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Air Force Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: PMW-1D
Site Location: Bldg 324 **OU #**
Installation Date 6/4/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 0.5
Approximate Diameter of Borehole (in): 3.75
Top of Pellet Seal (ft bgs): 11.0
Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:
Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 29.0
Top of Pre-Pack Assembly (ft bgs): 29.7
Top of Screen Interval (ft bgs): 29.8
Bottom of Screen Interval (ft): 32.8
Bottom of Pre-Pack Assembly (ft): 33
Bottom of Borehole (ft): 33.0

Ground Seal (Surface Pad)
Dimensions: 18-inch x 18-inch x 4-inch
Type: Concrete

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co Inc.
Product Name: Pel-Plug TR30
Size: 1/4 inch diameter
Volume Added (ft^3):
Installation: Gravity* Tremie
* throgh the Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1.25 inch

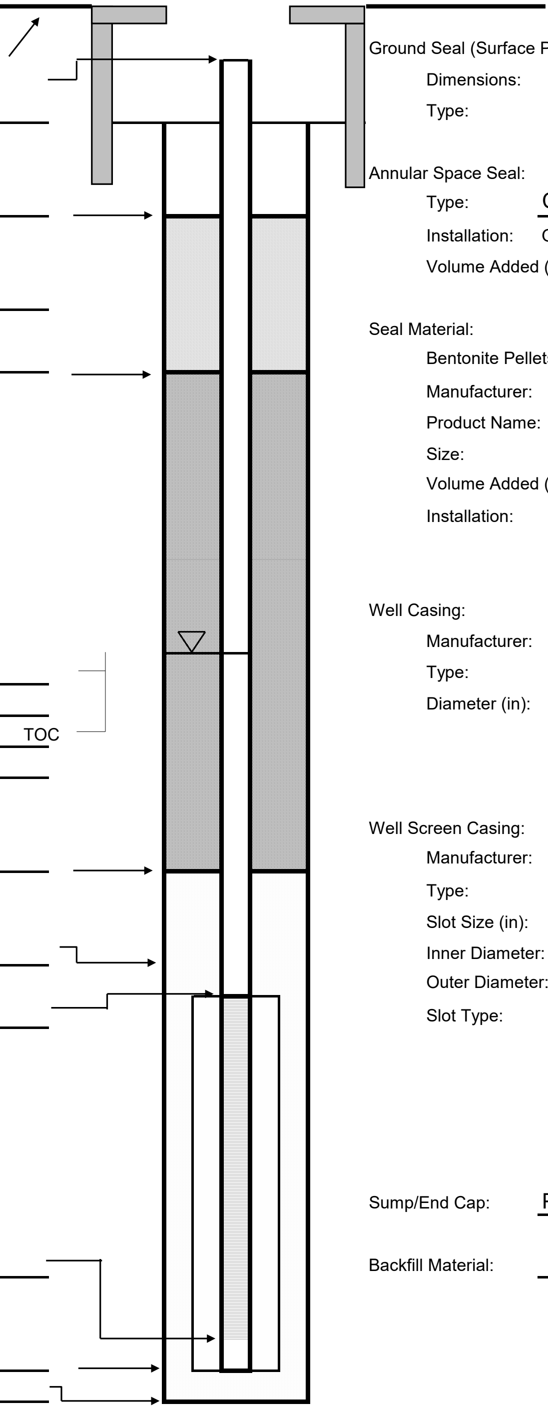
Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.010
Inner Diameter: 1.25"
Outer Diameter: 2.8"
Slot Type: Factory slot

Sump/End Cap: PVC - 0.2-foot
Backfill Material:

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Monitoring Well Construction Log

Project:	**Cometabolic Biosparging: Large Dilute Plume**	**Well Number:**	PMW-2I
Location:	**Former Myrtle Beach Air Force Base - South Carolina**	**Site Location:**	**Bldg 324** OU #
Client:	**ESTCP**	**Installation Date**	**6/3/2019**
Subcontractor:	**APTIM**	**Northing:**	
Driller:	**Cascade - Charles Terry - License B2080**	**Easting:**	
APTIM Field Representative:	**A. R. Tingle**	**Project Number:**	**500814**



Land Surface Elevation (ft msl):

Top of Casing Elevation (ft msl):

Top of Annular Seal (ft bgs): 0.5

Approximate Diameter of Borehole (in): 3.75

Top of Pellet Seal (ft bgs): 11.0

Depth to Water (ft bgs):

During Drilling:

Date:

Post Development: TOC

Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 23.5

Top of Pre-Pack Assembly (ft bgs): 24.6

Top of Screen Interval (ft bgs): 24.7

Bottom of Screen Interval (ft): 27.7

Bottom of Pre-Pack Assembly (ft): 27.9

Bottom of Borehole (ft): 27.9

Ground Seal (Surface Pad)

Dimensions: 18-inch x 18-inch x 4-inch

Type: Concrete

Annular Space Seal:

Type: Cement Bentonite Grout

Installation: Gravity Tremie Pumped

Volume Added (gal):

Seal Material:

Bentonite Pellets

Manufacturer: PDS Co Inc.

Product Name: Pel-Plug TR30

Size: 1/4 inch diameter

Volume Added (ft^3):

Installation: Gravity* Tremie

* throgh the Geoprobe rods

Well Casing:

Manufacturer: Johnson

Type: Schedule 40 PVC

Diameter (in): 1.25 inch

Well Screen Casing:

Manufacturer: Johnson

Type: Prepack

Slot Size (in): 0.010

Inner Diameter: 1.25"

Outer Diameter: 2.8"

Slot Type: Factory slot

Sump/End Cap: PVC - 0.2-foot

Backfill Material:

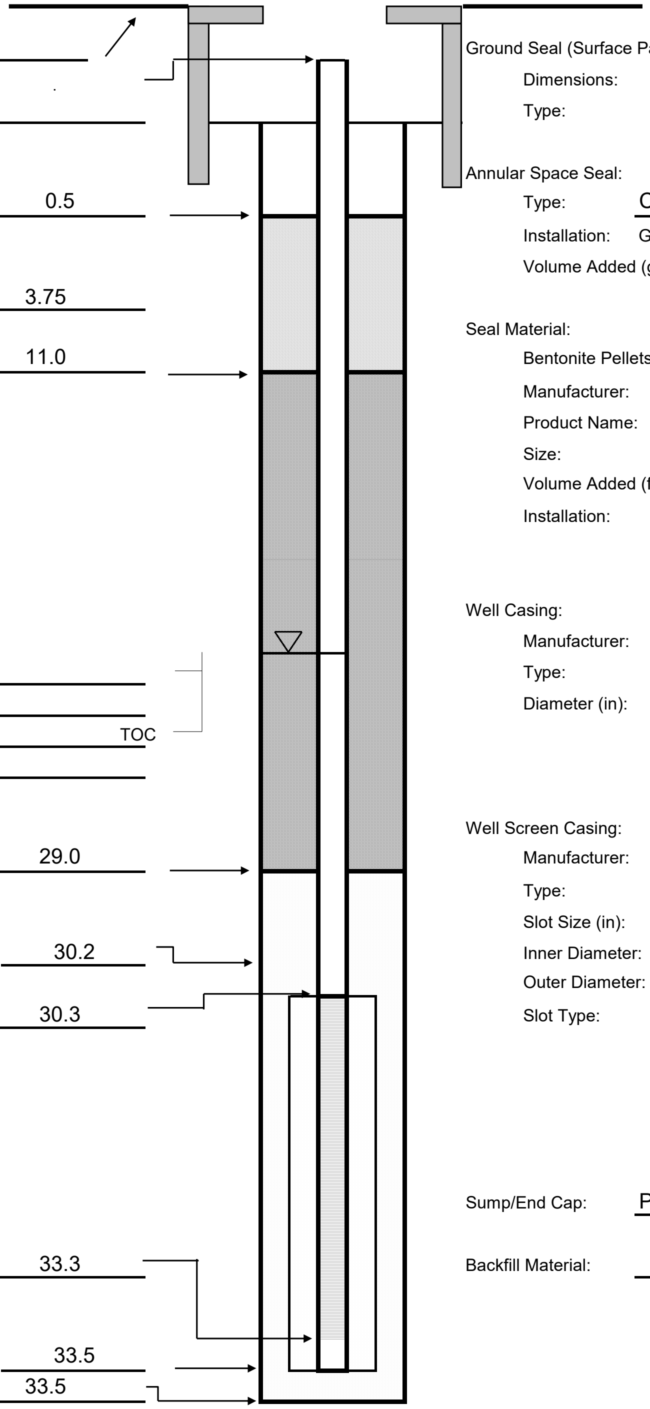
APTIM

Depths and heights are referenced to ground surface unless specified TOC.

All elevations are referenced to MSL (NAVD 88).

Monitoring Well Construction Log

Project:	**Cometabolic Biosparging: Large Dilute Plume**	**Well Number:**	PMW-2D
Location:	**Former Myrtle Beach Air Force Base - South Carolina**	**Site Location:**	**Bldg 324** OU #
Client:	**ESTCP**	**Installation Date**	**6/3/2019**
Subcontractor:	**APTIM**	**Northing:**	
Driller:	**Cascade - Charles Terry - License B2080**	**Easting:**	
APTIM Field Representative:	**A. R. Tingle**	**Project Number:**	**500814**



Land Surface Elevation (ft msl):

Top of Casing Elevation (ft msl):

Top of Annular Seal (ft bgs): 0.5

Approximate Diameter of Borehole (in): 3.75

Top of Pellet Seal (ft bgs): 11.0

Depth to Water (ft bgs):

During Drilling:

Date:

Post Development: TOC

Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 29.0

Top of Pre-Pack Assembly (ft bgs): 30.2

Top of Screen Interval (ft bgs): 30.3

Bottom of Screen Interval (ft): 33.3

Bottom of Pre-Pack Assembly (ft): 33.5

Bottom of Borehole (ft): 33.5

Ground Seal (Surface Pad)

Dimensions: 18-inch x 18-inch x 4-inch

Type: Concrete

Annular Space Seal:

Type: Cement Bentonite Grout

Installation: Gravity Tremie Pumped

Volume Added (gal):

Seal Material:

Bentonite Pellets

Manufacturer: PDS Co Inc.

Product Name: Pel-Plug TR30

Size: 1/4 inch diameter

Volume Added (ft^3):

Installation: Gravity* Tremie

* throgh the Geoprobe rods

Well Casing:

Manufacturer: Johnson

Type: Schedule 40 PVC

Diameter (in): 1.25 inch

Well Screen Casing:

Manufacturer: Johnson

Type: Prepack

Slot Size (in): 0.010

Inner Diameter: 1.25"

Outer Diameter: 2.8"

Slot Type: Factory slot

Sump/End Cap: PVC - 0.2-foot

Backfill Material:

APTIM

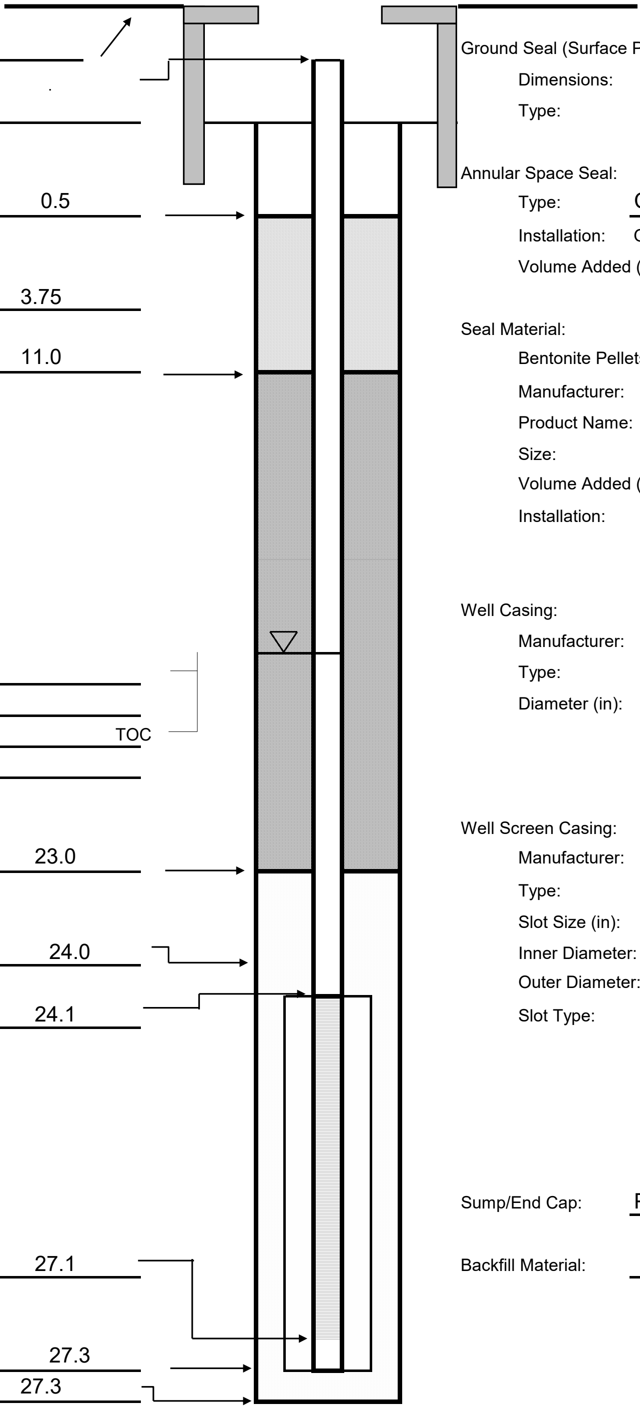
Depths and heights are referenced to ground surface unless specified TOC.

All elevations are referenced to MSL (NAVD 88).

Monitoring Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Air Force Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: PMW-3I
Site Location: Bldg 324 OU #
Installation Date 6/4/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 0.5
Approximate Diameter of Borehole (in): 3.75
Top of Pellet Seal (ft bgs): 11.0
Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:
Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 23.0
Top of Pre-Pack Assembly (ft bgs): 24.0
Top of Screen Interval (ft bgs): 24.1
Bottom of Screen Interval (ft): 27.1
Bottom of Pre-Pack Assembly (ft): 27.3
Bottom of Borehole (ft): 27.3

Ground Seal (Surface Pad)
Dimensions: 18-inch x 18-inch x 4-inch
Type: Concrete

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co Inc.
Product Name: Pel-Plug TR30
Size: 1/4 inch diameter
Volume Added (ft^3):
Installation: Gravity* Tremie
* throgh the Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1.25 inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.010
Inner Diameter: 1.25"
Outer Diameter: 2.8"
Slot Type: Factory slot

Sump/End Cap: PVC - 0.2-foot
Backfill Material:

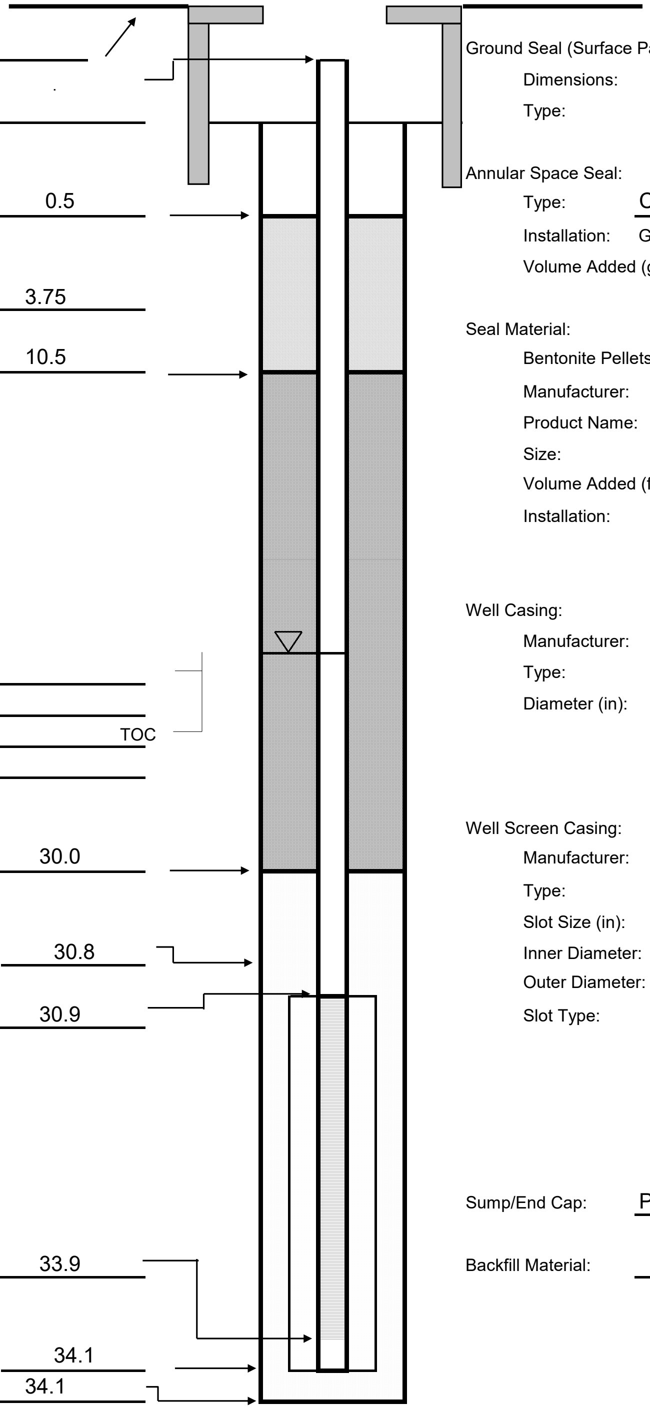
APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Monitoring Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Air Force Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: PMW-3D
Site Location: Bldg 324 OU #
Installation Date 6/4/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 0.5
Approximate Diameter of Borehole (in): 3.75
Top of Pellet Seal (ft bgs): 10.5
Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:
Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 30.0
Top of Pre-Pack Assembly (ft bgs): 30.8
Top of Screen Interval (ft bgs): 30.9
Bottom of Screen Interval (ft): 33.9
Bottom of Pre-Pack Assembly (ft): 34.1
Bottom of Borehole (ft): 34.1

Ground Seal (Surface Pad)
Dimensions: 18-inch x 18-inch x 4-inch
Type: Concrete

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co Inc.
Product Name: Pel-Plug TR30
Size: 1/4 inch diameter
Volume Added (ft^3):
Installation: Gravity* Tremie
* throgh the Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1.25 inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.010
Inner Diameter: 1.25"
Outer Diameter: 2.8"
Slot Type: Factory slot

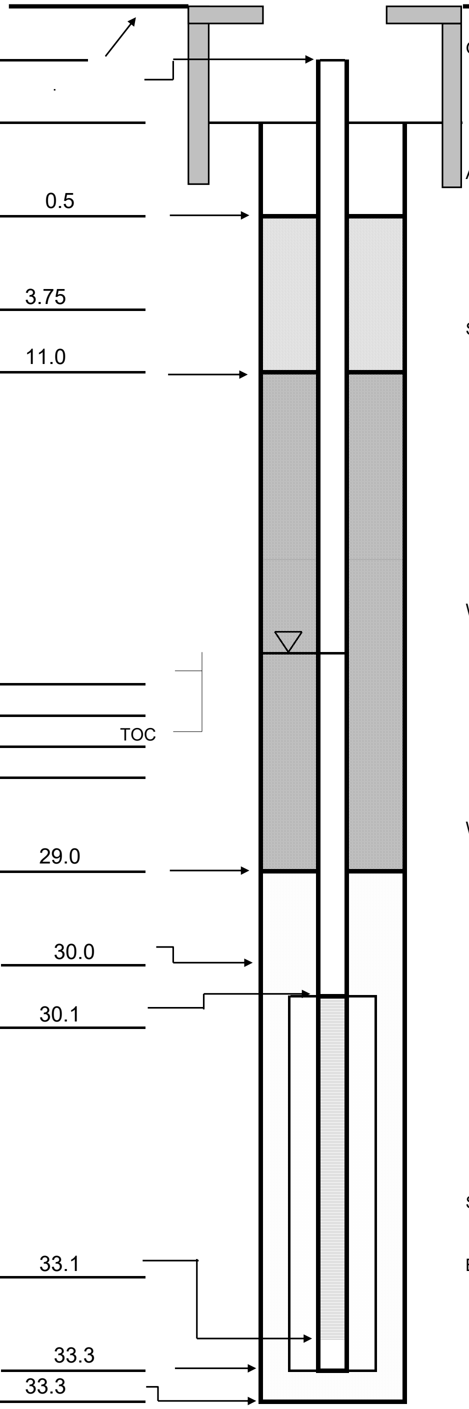
Sump/End Cap: PVC - 0.2-foot
Backfill Material:

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Monitoring Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Air Force Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: PMW-4D
Site Location: Bldg 324 OU #
Installation Date 6/4/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 0.5
Approximate Diameter of Borehole (in): 3.75
Top of Pellet Seal (ft bgs): 11.0
Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:
Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 29.0
Top of Pre-Pack Assembly (ft bgs): 30.0
Top of Screen Interval (ft bgs): 30.1
Bottom of Screen Interval (ft): 33.1
Bottom of Pre-Pack Assembly (ft): 33.3
Bottom of Borehole (ft): 33.3

Ground Seal (Surface Pad)
Dimensions: 18-inch x 18-inch x 4-inch
Type: Concrete

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co Inc.
Product Name: Pel-Plug TR30
Size: 1/4 inch diameter
Volume Added (ft^3):
Installation: Gravity* Tremie
* throgh the Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1.25 inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.010
Inner Diameter: 1.25"
Outer Diameter: 2.8"
Slot Type: Factory slot

Sump/End Cap: PVC - 0.2-foot
Backfill Material:

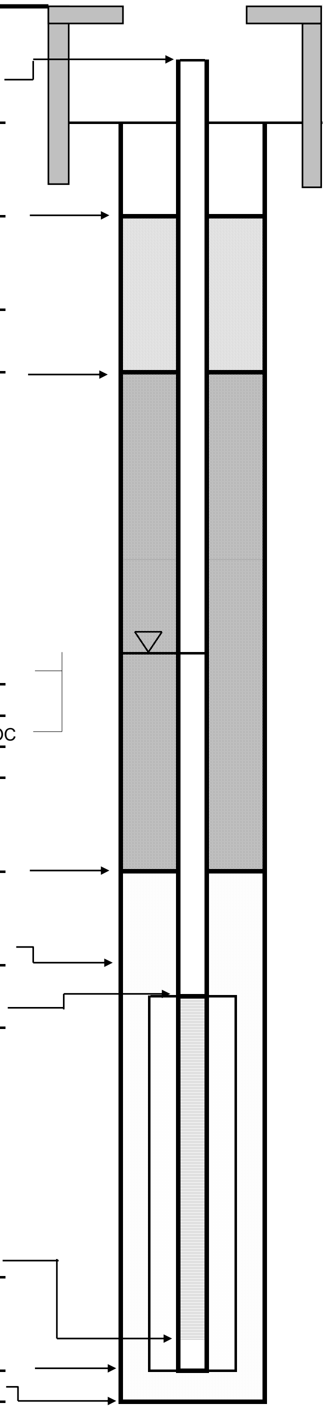
APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Monitoring Well Construction Log

Project: Cometabolic Biosparging: Large Dilute Plume
Location: Former Myrtle Beach Air Force Base - South Carolina
Client: ESTCP
Subcontractor: APTIM
Driller: Cascade - Charles Terry - License B2080
APTIM Field Representative: A. R. Tingle

Well Number: BMW-1I
Site Location: Bldg 324 OU #
Installation Date 6/3/2019
Northing:
Easting:
Project Number: 500814



Land Surface Elevation (ft msl):
Top of Casing Elevation (ft msl):
Top of Annular Seal (ft bgs): 0.5
Approximate Diameter of Borehole (in): 3.75
Top of Pellet Seal (ft bgs): 11.0
Depth to Water (ft bgs):
During Drilling:
Date:
Post Development: TOC
Date:
Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 24.0
Top of Pre-Pack Assembly (ft bgs): 24.5
Top of Screen Interval (ft bgs): 24.6
Bottom of Screen Interval (ft): 27.6
Bottom of Pre-Pack Assembly (ft): 27.8
Bottom of Borehole (ft): 27.8

Ground Seal (Surface Pad)
Dimensions: 18-inch x 18-inch x 4-inch
Type: Concrete

Annular Space Seal:
Type: Cement Bentonite Grout
Installation: Gravity Tremie Pumped
Volume Added (gal):

Seal Material:
Bentonite Pellets
Manufacturer: PDS Co Inc.
Product Name: Pel-Plug TR30
Size: 1/4 inch diameter
Volume Added (ft^3):
Installation: Gravity* Tremie
* throgh the Geoprobe rods

Well Casing:
Manufacturer: Johnson
Type: Schedule 40 PVC
Diameter (in): 1.25 inch

Well Screen Casing:
Manufacturer: Johnson
Type: Prepack
Slot Size (in): 0.010
Inner Diameter: 1.25"
Outer Diameter: 2.8"
Slot Type: Factory slot

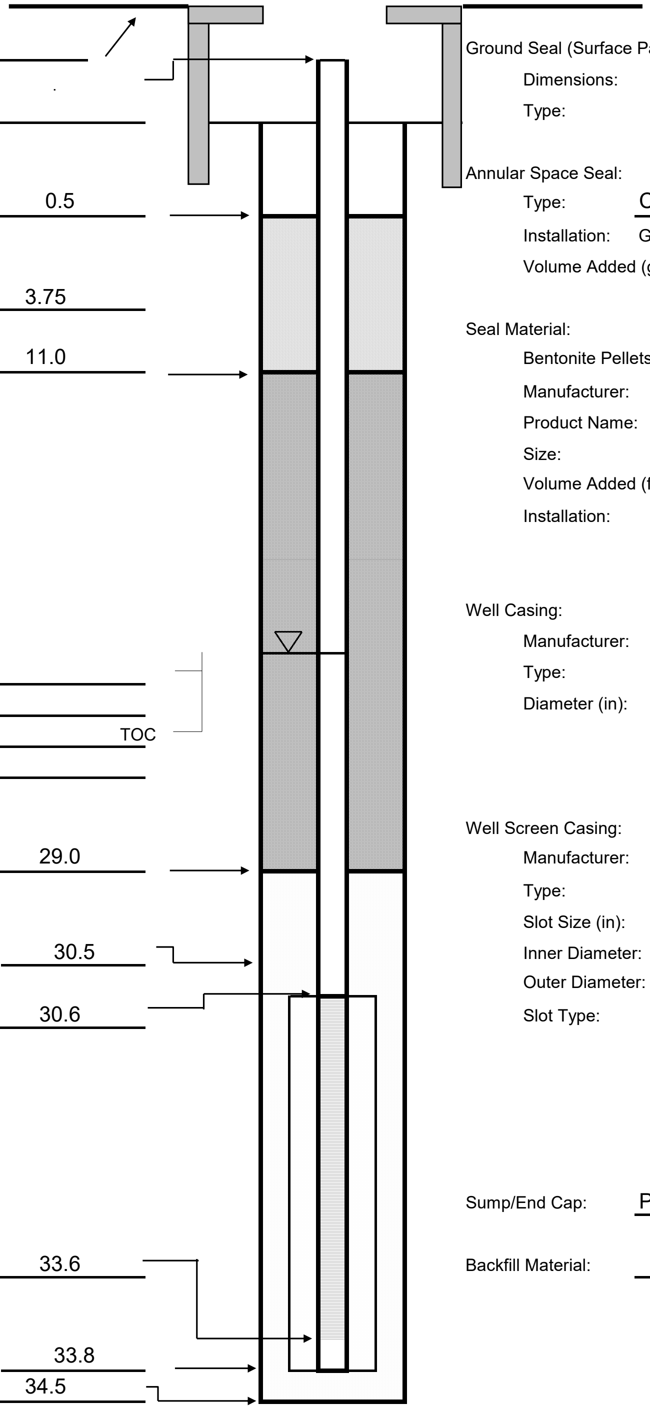
Sump/End Cap: PVC - 0.2-foot
Backfill Material:

APTIM

Depths and heights are referenced to ground surface unless specified TOC.
All elevations are referenced to MSL (NAVD 88).

Monitoring Well Construction Log

Project:	**Cometabolic Biosparging: Large Dilute Plume**	**Well Number:**	BMW-1D
Location:	**Former Myrtle Beach Air Force Base - South Carolina**	**Site Location:**	**Bldg 324** OU #
Client:	**ESTCP**	**Installation Date**	**6/4/2019**
Subcontractor:	**APTIM**	**Northing:**	
Driller:	**Cascade - Charles Terry - License B2080**	**Easting:**	
APTIM Field Representative:	**A. R. Tingle**	**Project Number:**	**500814**



Land Surface Elevation (ft msl):

Top of Casing Elevation (ft msl):

Top of Annular Seal (ft bgs): 0.5

Approximate Diameter of Borehole (in): 3.75

Top of Pellet Seal (ft bgs): 11.0

Depth to Water (ft bgs):

During Drilling:

Date:

Post Development:

Date:

Top of Natural Collapse / bottom of Pellet Seal (ft bgs): 29.0

Top of Pre-Pack Assembly (ft bgs): 30.5

Top of Screen Interval (ft bgs): 30.6

Bottom of Screen Interval (ft): 33.6

Bottom of Pre-Pack Assembly (ft): 33.8

Bottom of Borehole (ft): 34.5

Ground Seal (Surface Pad)

Dimensions: 18-inch x 18-inch x 4-inch

Type: Concrete

Annular Space Seal:

Type: Cement Bentonite Grout

Installation: Gravity Tremie Pumped

Volume Added (gal):

Seal Material:

Bentonite Pellets

Manufacturer: PDS Co Inc.

Product Name: Pel-Plug TR30

Size: 1/4 inch diameter

Volume Added (ft^3):

Installation: Gravity* Tremie

* throgh the Geoprobe rods

Well Casing:

Manufacturer: Johnson

Type: Schedule 40 PVC

Diameter (in): 1.25 inch

Well Screen Casing:

Manufacturer: Johnson

Type: Prepack

Slot Size (in): 0.010

Inner Diameter: 1.25"

Outer Diameter: 2.8"

Slot Type: Factory slot

Sump/End Cap: PVC - 0.2-foot

Backfill Material: COLLAPSE

APTIM

Depths and heights are referenced to ground surface unless specified TOC.

All elevations are referenced to MSL (NAVD 88).

APPENDIX C TREATABILITY STUDY REPORT

Evaluation of a Sustainable and Passive Approach to Treat Large, Dilute Chlorinated VOC Groundwater Plumes

ESTCP PROJECT ER-201629
Treatability Study Report

Prepared by

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Draft Version 1

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	Full text
µg/L	micrograms per liter
AFB	Air Force Base
AFCEC	Air Force Civil Engineer Center
bgs	below ground surface
BSM	Basal Salts Medium
CB&I	Chicago Bridge and Iron Federal Services
cis-DCE	*cis*-1,2-Dichloroethene
CFM	cubic feet per minute
cVOC	Chlorinated Volatile Organic Compound
1,4-D	1,4-dioxane
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
DoD	United States Department of Defense
EDB	1,2-dibromoethane
ESTCP	Environmental Security Technology Certification Program
ft	foot or feet
GC/FID	gas chromatography/flame ionization detector
GC/TCD	gas chromatography/thermal conductivity detector
MBAFB	Myrtle Beach Air Force Base
MCL	Maximum Contaminant Level
mg/L	milligrams per liter
mL	milliliter(s)
NDMA	*N*-Nitrosodimethylamine
ng/L	nanograms per liter
O&M	Operation and Maintenance
ORP	Oxidation-Reduction Potential
PCE	Tetrachloroethene
PMW	Performance Monitoring Well
STW	Sparge Testing Well
TCE	trichloroethene
VC	vinyl chloride
VOC	Volatile Organic Compound

1.0 INTRODUCTION

1.1 BACKGROUND

Chlorinated volatile organic compounds (cVOCs) continue to be primary contaminants of concern for the US Department of Defense (DoD), even though many suitable treatment technologies have been developed and verified. One of the greatest challenges remaining for remediating these contaminants at DoD sites and protecting downgradient receptors is the treatment and/or control of large dilute plumes. Remedial costs are particularly high at sites where contamination is extensive, but concentrations are low. Current approaches to address large, dilute plumes are typically long-term and have high capital and operation and maintenance (O&M) costs.

Achieving clean-up levels for cVOCs and other organic pollutants in plumes that only have low part-per-billion (i.e., μg/L) concentrations is a difficult technological challenge. Cometabolism is showing significant promise in this area because organisms grow aerobically on a supplied substrate (e.g., propane or methane) rather than the trace contaminant, allowing good degradation kinetics, minimal impacts to aquifer geochemistry, and the ability to achieve ng/L contaminant concentrations (e.g., Fournier et al., 2009, Lippincott et al., 2015; Hatzinger et al., 2011, 2015, Hatzinger and Begley, 2014). However, to meet current DoD needs, this technology needs to be demonstrated in a sustainable, cost effective manner for treatment of a large, dilute plume. That is the key objective of this work.

As discussed in the Site Selection Memorandum (CB&I, 2017), several sites were evaluated during the site selection process. While some of these sites were determined to be suitable for application of this remedial approach, based on the site selection criteria rating presented in the Memorandum, the Building 324 plume at former Myrtle Beach Air Force Base (MBAFB) was determined to be the most appropriate location for demonstrating this remedial approach (**Figure 1.1**). The Building 324 location (Site) has many characteristics that make it ideal for this demonstration, including site accessibility, the presence of a large, dilute cVOC plume (~210 ft wide), a reasonable depth (~35 ft) and thickness (~15 ft) of the target treatment interval, a permeable aquifer that is amenable to sparging, significant historical cVOC concentration data, and existing monitoring wells.

This project entails cometabolic biosparging using a line of biosparging wells installed perpendicular to groundwater flow across the width of a large, dilute cVOC plume containing *cis*-1,2-dichloroethene (*cis*-DCE) and vinyl chloride (VC). Contaminated groundwater will be treated as it flows through a biologically active zone (i.e. bio-curtain) created by biosparging air (or oxygen), an alkane gaseous substrate (propane), and a gaseous nutrient (ammonia) to stimulate indigenous bacteria capable of degrading *cis*-DCE and VC to below their respective maximum contaminant levels (MCLs) of 70 μg/L and 2 μg/L. The biosparging system will be designed and constructed to operate completely "off-the-grid", using existing sustainable energy technologies.

1.2 OBJECTIVES OF THE DEMONSTRATION

The overall goal of this project is to demonstrate effective *in situ* biological treatment of large, dilute cVOC plumes using an approach that is both sustainable and cost effective. The critical objectives of this demonstration are to determine whether an off-the-grid biosparging system can sustainably and economically deliver gaseous amendments across a large, dilute plume, stimulating indigenous bacteria to biodegrade target cVOCs, and whether consistent *in situ* treatment of these cVOCs to target levels (i.e., MCLs) is feasible. Specific performance objectives that will be used to evaluate this technology during the demonstration are provided in detail in the Site Selection Memo (CB&I, 2017).

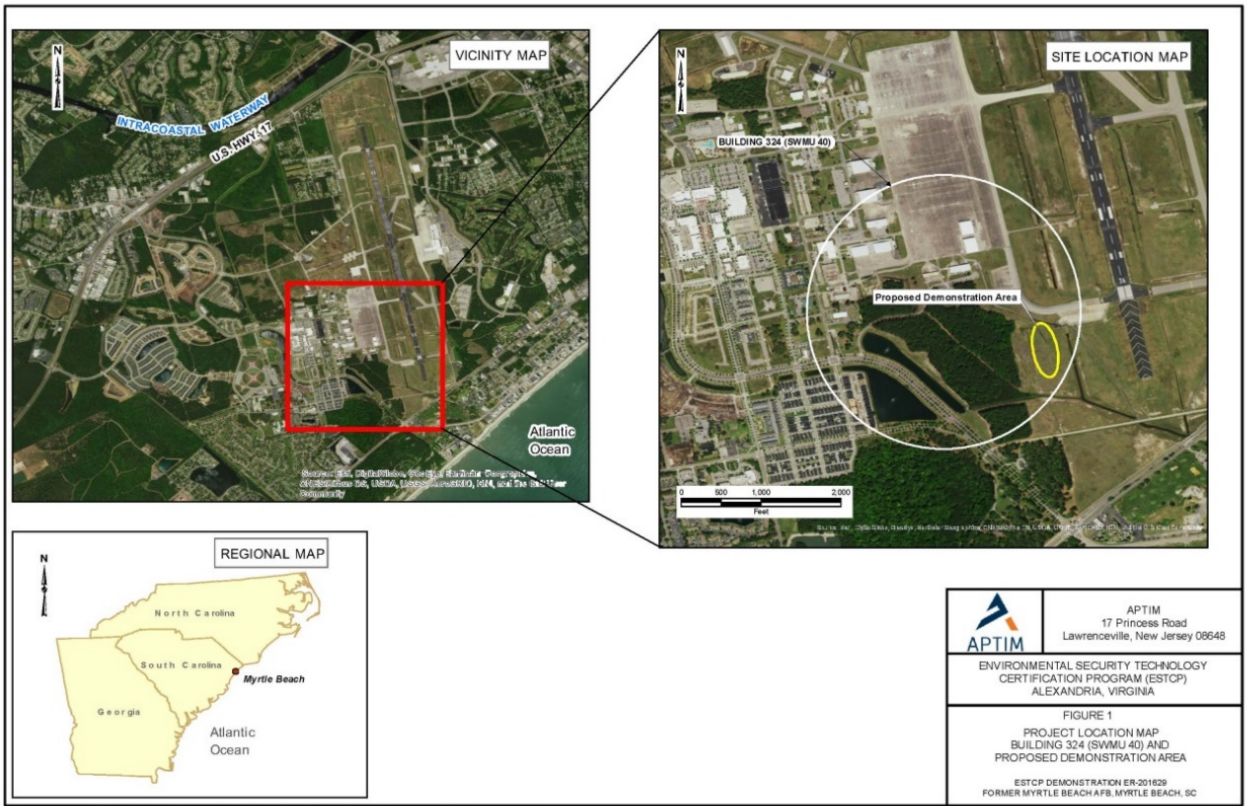


Figure 1.1. Project Location Map: Building 324 and Demonstration Area

2.0 TECHNOLOGY DESCRIPTION

The underlying approach of gas biosparging using primary cometabolic substrates is mature, cost effective, and can be safely applied in a number of different configurations based on site conditions. The fundamental concepts supporting this field demonstration are (1) the utilization of aerobic cometabolism for *in situ* degradation of an environmental pollutant, and (2) distribution of gases in the subsurface to stimulate pollutant biodegradation. Each of these concepts are supported by extensive laboratory research and, more recently, field testing. The first publications on cometabolic reactions and their potential applications for remediation date to the 1960s (Alexander, 1967), and scientific research was conducted on the cometabolism of many different compounds thereafter (Alexander, 1994 and references therein). The observation that methanotrophic bacteria are capable of dechlorinating trichloroethene (TCE) and other chlorinated ethenes and ethanes (Oldenhuis et al., 1989) and that this process can be stimulated *in situ* (Wilson and Wilson, 1985) resulted in the initial field testing of cometabolic degradation for chlorinated solvent remediation (Hazen et al., 1994; Semprini and McCarty, 1991). Since this time, cometabolic degradation of chlorinated solvents by phenol- and toluene-degrading bacteria has been examined in the field (Hopkins and McCarty, 1995; McCarty et al., 1998), as has the application of propane-oxidizing bacteria for *in situ* treatment of chlorinated solvents (Battelle, 2001; Tovanabootr et al., 2001) and gasoline oxygenates (Steffan et al., 2003).

More recent successful field applications of cometabolism have centered around the treatment of several DoD emerging contaminants, including 1,2-dibromoethane (EDB), N-nitrosodimethylamine (NDMA), and 1,4-dioxane (1,4-D). One of the key considerations with these contaminants is that they often occur in aquifers at very low concentrations (e.g., low microgram per liter (µg/L) range), but still require treatment to meet state or federal regulations that can be in the nanogram per liter (ng/L) range. Cometabolism has proven to be one of the only viable *in situ* technologies to meet these objectives. Most recently, ESTCP funded a field demonstration for cometabolic treatment of NDMA (ER-200828; *Field Demonstration of Propane Biosparging for In Situ Remediation of NDMA in Groundwater*) at the Aerojet facility in Rancho Cordova, CA, and the Air Force Civil Engineer Center (AFCEC) funded field demonstrations for cometabolic treatment of 1,4-D (BAA Project 518; *Remediation of 1,4-Dioxane Contaminated Aquifers*) at Vandenberg Air Force Base (AFB) in California (Lippincott et al., 2015), and EDB (BAA Project 576; *Enhanced In Situ Bioremediation of EDB at Joint Base Cape Cod*) at Joint Base Cape Cod, MA (Hatzinger and Begley 2014; Hatzinger et al., 2015). Each of these field demonstrations showed that target contaminants could be treated *in situ* to below relevant cleanup or health advisory levels using cometabolic remediation. Results from the Vandenberg AFB demonstration, while focused on 1,4-D, also showed that MCLs for several cVOCs (including TCE, *cis*-DCE), 1,1-dichloroethene (1,1-DCE), 1,1-dichloroethane (1,1-DCA) and chloroform) could be attained via cometabolic processes using a biosparging approach on a small scale. As the general approach of cometabolic biosparging has been successfully field-tested, the results from these demonstrations (and the lessons learned) will be utilized during the design of this full-scale field trial.

3.0 TREATABILITY STUDY DESIGN AND IMPLEMENTATION

3.1 STUDY OBJECTIVES

Laboratory treatability studies were conducted with aquifer samples obtained during site characterization activities. The first studies performed consisted of microcosms established using site soil and groundwater. The primary objectives of the microcosm study were to determine the efficacy of oxygen and various alkane/alkene gases (propane, methane, ethene, and natural gas) to stimulate co-metabolic treatment of target cVOCs using indigenous microbial populations, and to determine if nutrient addition (nitrogen and phosphorous) would be required/beneficial for this process. Typically, alkane/alkene gases of high purity (>99% pure) are used in laboratory treatability studies and field applications to minimize potential microbial inhibition due to impurities or additives (e.g., propylene, acetylene, mercaptans, etc.). Recent work (unpublished) by our laboratory indicates that industrial and consumer grade propane are not ideal gaseous substrates for bacterial growth and effective cometabolic treatment of cVOCs (likely due to the relatively high concentration of propene present in these gases). Therefore, these lower grade propanes were not tested during this study. However, some of the microcosms in this study included the addition of commercially available natural gas, which is composed of approximately 95% methane (with the balance of gases being primarily ethane, propane, butane and nitrogen) with mercaptan additive as an odorant for safety. These microcosms were established to determine if this type of commercially available lower purity gas might be effective during field implementation of this remedial approach.

Based on their effectiveness at promoting cVOC degradation during the microcosm studies, propane and ethene were selected for further study. As detailed in **Section 3.4**, batch kinetic studies were conducted with these gasses and mixed enrichment cultures were derived from select microcosm bottles. During these studies we; 1) examined individual compounds of concern (*cis*-DCE, and VC) and focused on the utilization of the selected substrate gas for biodegradation of these compounds, and 2) assessed inhibition of each gas on cVOC degradation. The information derived from the batch kinetic studies helped inform design (particularly, substrate gas sparging frequency and duration) of the demonstration system to maximize treatment efficacy.

3.2 AQUIFER MATERIAL COLLECTION

As discussed in Section 1.1, the Building 324 plume at former MBAFB was selected as the location for the field demonstration. Soil and groundwater used in microcosms were collected from the demonstration site during site characterization activities. Intact soil core samples were collected from the saturated zone using direct-push drilling techniques. Continuous soil cores were collected using a 60-inch long, 2.25-inch outer diameter Geoprobe soil sampling tool fitted with an approximate 1.3” inner diameter liner. The cores were logged in the field by an APTIM geologist, and permeable aquifer material was collected from select core sections. Soil from depth intervals of 20.0 to 34.0 ft below ground surface (bgs) and 43-50 ft bgs were removed from the cores, transferred to 5-L sealable bags, and marked with the location, depth intervals, and collection date. Collection of intact, sealed cores was not required, as laboratory treatability testing was performed under aerobic conditions. The aquifer material was shipped overnight to APTIM’s laboratory in Lawrenceville, NJ in coolers with ice. The soil samples were received by APTIM on September 8, 2017.

Groundwater for microcosms was collected on October 9, 2017 from well MB-30, which is located within the demonstration area. Groundwater was sampled from the well using low-flow methods (e.g., Puls and Barcelona, 1996), after stabilization of field parameters (temperature, pH, ORP, dissolved oxygen and specific conductivity). Groundwater samples were collected in eight sterile, unpreserved 1-L amber bottles (capped with Teflon®-lined lids) and three 40-mL HCl-preserved sample bottles, placed in a cooler on ice, and shipped overnight to APTIM's treatability study lab. Results from laboratory analysis of the preserved 40-mL sample bottles indicated VC and *cis*-DCE concentrations of 40 µg/L and 80 µg/L, respectively.

Upon receipt, the soil and groundwater samples were logged in and stored at approximately 4°C until initiation of the study. Based on discrete groundwater sampling data collected during site characterization activities, soil from 28.9-34 ft bgs was chosen to be used in the microcosms. The selected soil was homogenized by hand on a sterile surface using a modified cone-and-quarter technique. All laboratory materials were ethanol-washed or autoclaved prior to contact with Site soil. Groundwater was homogenized by pouring the contents of the eight individual 1-L sample bottles into one large, sterile (i.e., autoclaved) glass container. The combined groundwater was then stirred to thoroughly mix the contents and pH taken (approximately 6.67 SU). Homogenization was performed aerobically at ambient laboratory temperature.

3.3 MICROCOSM STUDIES

3.3.1 Microcosm Set Up

Microcosms were prepared in borosilicate glass serum bottles (approximate volume, 160 mL). Approximately 30 g of homogenized Site soil (**Figure 3.1**) and 100 mL of Site groundwater were added to each microcosm (**Figure 3.2**), leaving approximately 40 mL of room air in the headspace. The bottles were sealed with Teflon®-lined butyl rubber stoppers and aluminum crimp caps. The microcosms were spiked to achieve an approximate starting aqueous concentration of 250 µg/L of both *cis*-DCE and VC.

Figure 3.1. Photograph of Homogenized Soil Added to Serum Bottles

Figure 3.2. Photograph of Microcosms Set Up With Site Soil and Groundwater

As summarized in **Table 3.1**, the microcosm study consisted of a total of 19 treatments. Treatments 1 through 15 were prepared in triplicate and 16 through 19 were prepared in duplicate (**Figures 3.1** and **3.2**). Separate microcosm treatments were established for each of the four substrate gases (propane, methane, ethene and natural gas). The microcosms received the substrate gas in the headspace at a concentration that was ~ 75% of their respective lower explosive limit (LEL). Separate treatments for each gas were set up with and without inorganic nutrients (nitrogen & phosphorus). Two combinations of gaseous inorganic nutrients that could potentially enhance the degradation of the substrate gases and target contaiminants during biosparging were added to separate treatments as follows:

- 0.75% headspace as nitrous oxide (N_2O) with 10 mg/L triethylphosphate (TEP) in Treatments 5, 8, 11 and 14, and
- 10 mg/L methylamine (MA) with 10 mg/L TEP in Treatments 6, 9, 12, and 15

Additionally, duplicate bottles (Treatments 16 through 19) were set up with 50 mg/L diammonium phosphate (DAP) to serve as positive controls, as this compound has been consistently shown to be an effective nutrient source in biological degradation activities (e.g., Hatzinger et al., 2015; Hatzinger and Begley, 2014). However, DAP cannot be used during the field demonstration because it is not a gaseous amendment that could be added to the sparge gas stream.

Killed controls (Treatment 1) received methane gas, air and inorganic nutrients in the headspace. These microcosms also received 2,000 mg/L mercuric chloride and 0.1% v/v formaldehyde to inhibit microbial activity. These microcosms were established to evaluate abiotic losses of cVOCs and methane (as a representative alkane gas). Two sets of Live controls (Treatments 2 and 3) also received the above combinations of inorganic nutrients and air in the headspace.

Table 3.1. Microcosm Treatment Summary

			Alkane/Alkene Gas			
Treatment Number	**Treatment Description**	**Headspace**	**Gas Purity (%)**	**Headspace (%)**	**Calculated Aqueous Concentration (µg/L)**	**Inorganic Nutrients Added**
Triplicate Microcosms						
1	Killed Control*	Air	99.0	3.8	760	Yes
2	Live + TEP & N$_2$0	Air	NA	NA	NA	Yes
3	Live + TEP & Methylamine	Air	NA	NA	NA	Yes
4	Propane	Air	99.0	1.6	870	No
5	Propane + TEP & N$_2$0	Air	99.0	1.6	870	Yes
6	Propane + TEP & Methylamine	Air	99.0	1.6	990	Yes
7	Methane	Air	99.5	3.8	760	No
8	Methane + TEP & N$_2$0	Air	99.5	3.8	760	Yes
9	Methane + TEP & Methylamine	Air	99.5	3.8	760	Yes
10	Ethene	Air	99.5	2.0	2190	No
11	Ethene + TEP & N$_2$0	Air	99.5	2.0	2190	Yes
12	Ethene + TEP & Methylamine	Air	99.5	2.0	2190	Yes
13	Natural Gas	Air	~95	3.8	760	No
14	Natural Gas + TEP & N$_2$0	Air	~95	3.8	760	Yes
15	Natural Gas + TEP & Methylamine	Air	~95	3.8	760	Yes
Duplicate Microcosms						
16	Propane + DAP	Air	99.0	1.6	870	Yes
17	Methane + DAP	Air	99.5	3.8	760	Yes
18	Ethene + DAP	Air	99.5	2.0	2190	Yes
19	Natural Gas + DAP	Air	~95	3.8	760	Yes

Notes:

*Killed Controls will receive 2,000 mg/L mercuric chloride and 0.1% v/v formaldehyde to inhibit microbial activity.

3.3.2 Microcosm Sampling and Analytical

After setup, the microcosms were shaken on an orbital shaker at ambient temperature. At each sampling event, microcosm bottles were removed from the shaker and allowed to settle so that the aqueous supernatant could be sampled. Aqueous samples were collected at approximately t=24 hours (to serve as an initial condition) for all treatments. Microcosms were subsequently sampled approximately once every 3 weeks for 12 weeks for cVOCs, yielding five time points in total. When not being sampled, microcosms remained at 22°C on a shaker. Propane and Ethene treatments containing either methylamine or DAP (Treatments 6, 12, 16, and 18) were spiked two additional times (days 50 and 71) with approximately 250 µg/L *cis*-DCE and VC. These treatments were each sampled an additional three time (for a total of 8 sampling events) to confirm spiked contaminant concentrations, and to monitor degradation of the target compounds after they were spiked.

Groundwater samples (8.5 mL) were collected through the septa using a glass gastight syringe equipped with a 25-gauge needle, preserved with HCl, and analyzed for cVOCs via EPA Method 8260. To prevent a vacuum, and to maintain aerobic conditions in the microcosms, the volume removed was replaced with sterile-filtered air to maintain desired oxygen concentrations in the headspace. Headspace monitoring was generally conducted on a weekly basis for the first month and biweekly thereafter for all treatments. Headspace substrate gas samples were analyzed on a gas chromatography/flame ionization detector (GC-FID), and headspace oxygen levels were measured on a gas chromatography/thermal conductivity detector (GC-TCD). The aliquots of headspace gas removed for these analyses was small (100 μL), and therefore did not require immediate replacement. If depletion of any of the substrate gases (propane, methane, ethene and natural gas) to below detectable limits (< 0.02μg/L methane and natural gas, <0.15μg/L ethene, and <0.07μg/L propane) was observed, the headspace gas was replenished back to the starting concentrations. If measured headspace oxygen concentrations fell below ~12%, oxygen was added to the microcosms to increase headspace oxygen concentrations to ~20%. Nutrients were replenished on day 48 in treatments where alkane/alkene gas degradation was observed (see section 3.3.3). Substrate gas and nutrient additions ended on day 48 of the study, to evaluate continued biodegradation in the absence of amendment addition. All samples were analyzed in APTIM's Lawrenceville, NJ laboratory.

3.3.3 Microcosm Results

The results of headspace alkane/alkene gas analyses are presented in four graphs in **Figure 3.3**. Headspace concentrations were converted to aqueous concentrations using Henry's Law, and data are presented as calculated aqueous concentrations in all graphs. The data show that propane and methane (in both the pure methane and natural gas treatments) were depleted and therefore re-added twice to microcosms that were amended with DAP or methylamine and TEP (Treatments 6, 9, 15, 16, 17 and 19) over the course of the study. Ethene, which started out at both higher aqueous and headspace concentrations (due to its higher LEL), was depleted and added once more to microcosms that were amended with these nutrients (Treatments 12 and 18). Near linear decreases in propane and ethene were observed in the treatments that did not receive nutrients and the treatments that received N_2O and TEP. Some, or all, of these decreases could be attributed to volatile losses during sampling, as similar losses in methane were observed in the killed control (Treatment 1). Methane was eventually depleted in both the pure methane and natural gas microcosms that did not receive nutrients (Treatments 7 and 13) and that received N_2O and TEP (Treatments 8 and 14) by the end of the 84-day study.

These data indicate that the addition of nutrients is required to stimulate biological activity in materials collected from the site. Specifically, DAP and the combination of methylamine and TEP were found to be effective nutrient sources, while the combination of N_2O and TEP was not effective at stimulating biological activity. The data suggest that the nitrogen in N_2O was not readily available to the cometabolic organisms in the aquifer materials as an assimilative nutrient, and thus is unlikely to be an effective gaseous nutrient for stimulating biological activity in the field. It is unclear whether this is a local phenomenon (i.e, indigenous cometabolic strains in this aquifer do not use N_2O as a nutrient) or more broadly applicable. Further research is required to evaluate how effective N_2O is as a N source for this type of application.

While it was evident from the above results that an effective source of N was required to enhance biological activity, the need to add a source of phosphorous (P) in conjunction with nitrogen was not clear, as P (in the form of DAP and TEP) was added to all the microcosms where primary substrate gases were rapidly depleted. Therefore, a follow-on microcosm study was performed that included the following treatments:

- Treatment #1: Killed treatment
- Treatment #2: Propane only
- Treatment #3: Propane plus methylamine
- Treatment #4: Propane plus methylamine and TEP

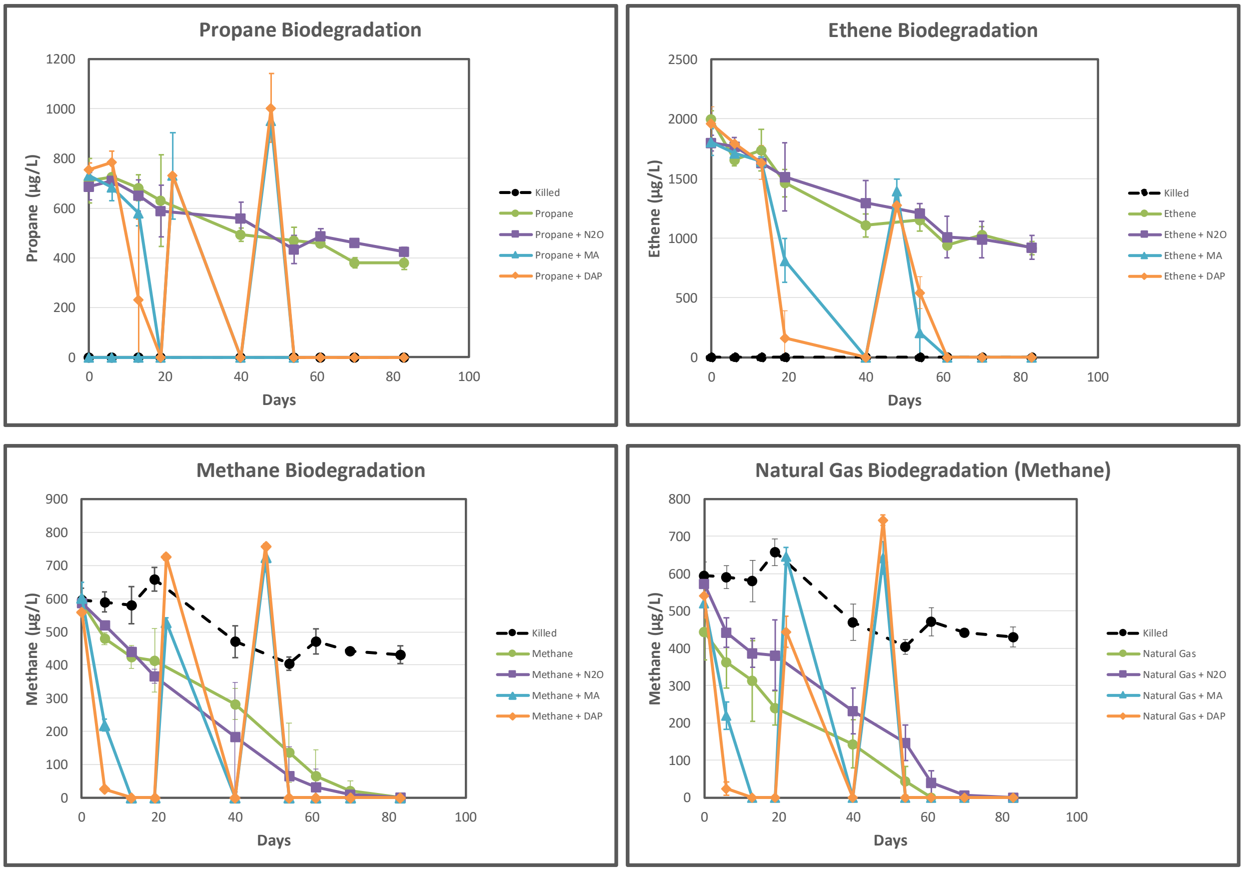


Figure 3.3. Degradation of Primary Gas Substrates in Microcosms

These microcosms were prepared and monitored as described for the previous microcosms, except that no cVOCs were added. Propane and oxygen were repeatedly added as they were rapidly consumed during the 169-day study. Nutrients were re-added to Treatments 3 and 4 on days 21, 33, and 68. Methylamine was replaced by ammonia (NH_3) in Treatment 3 on day 112 of the study to determine if gaseous ammonia might also be an effective nitrogen source for enhancing biological activity. Methylamine and TEP were added to Treatment 4 on day 112 as well.

The results of headspace propane gas analyses from this second study are presented in **Figure 3.4**. The data show that propane was depleted and re-added numerous times to microcosms that were amended with propane plus methylamine (Treatment 3) and propane plus methylamine and TEP (Treatment 4). No significant decreases in propane concentrations were observed in either the killed control (Treatment 1) or the microcosms amended with propane only (Treatment 2).

Reductions in propane degradation rates were observed in Treatments 3 and 4 between approximately days 89 and 112, after an extended period without the addition of nutrients. It was on day 112 that that the nitrogen source was switched from methylamine to NH_3 in Treatment 3, and methylamine and TEP were re-added to Treatment 4. As shown in **Figure 3.4**, propane degradation rates increased again after these nutrient additions. These data indicate that while a source of nitrogen is critical for stimulating biological activity in materials collected from the site, phosphorous does not appear to be a limiting nutrient. Furthermore, the data indicate that both methylamine and NH_3 are effective gaseous sources of nitrogen.

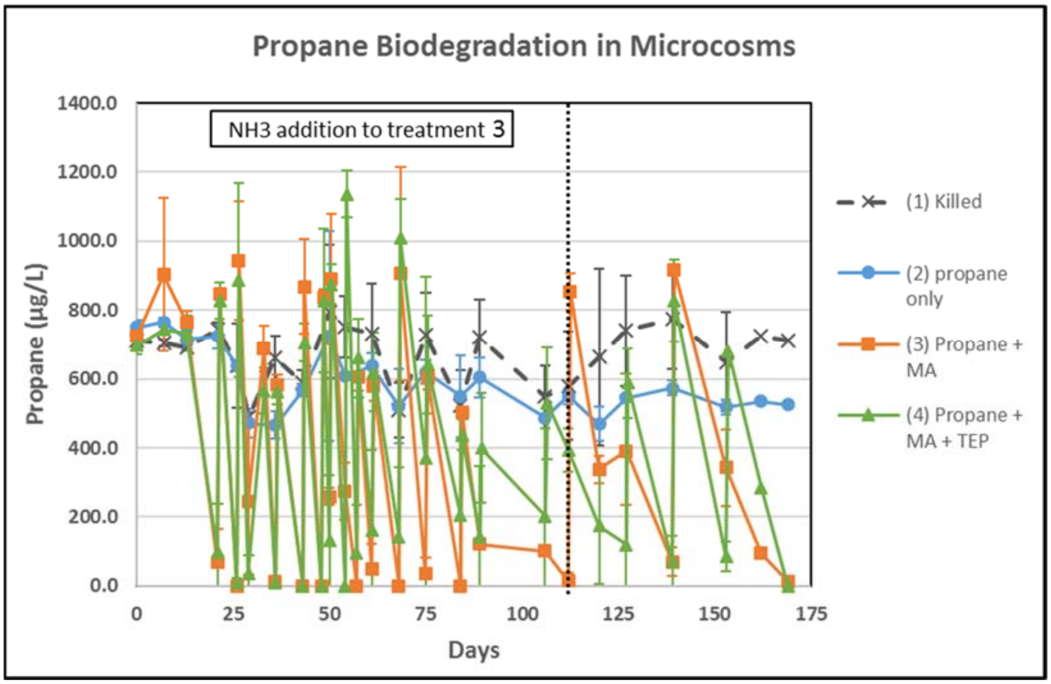


Figure 3.4. Degradation of Propane in Microcosms

Graphs summarizing VC and *cis*-DCE data collected from treatments amended with propane, ethene, methane and natural gas are presented in **Figure 3.5**. The data show that VC was degraded from between approximately 200 and 250 µg/L, to near or below detection (5 µg/L) in most of the treatments by the end of the study. However, no significant decreases in VC concentrations (relative to the killed control) were observed in the microcosms amended with ethene only (Treatment 10) or ethene plus N_2O and TEP (Treatment 11). This is likely due competitive inhibition caused by the high dissolved ethene concentrations measured in these treatments throughout the study (see **Figure 3.3**).

As shown on **Figure 3.5**, VC concentrations were below detection levels within 20 days in all of the microcosms amended with DAP (Treatments 16, 17, 18 and 19), and 3 of the 4 microcosms amended with methylamine and TEP (Treatments 6, 9 and 15). The fourth microcosm amended with methylamine and TEP (Treatment 12) exhibited high dissolved ethene concentrations (812 µg/L) at day 20, which likely inhibited the cometabolic degradation of VC. Complete biodegradation of VC was observed in this treatment by day 40, once the ethene in these microcosms had been consumed. Complete biodegradation of VC in the remaining treatments (with the exception of Treatments 10 and 11, as discussed above) generally took >60 days to occur.

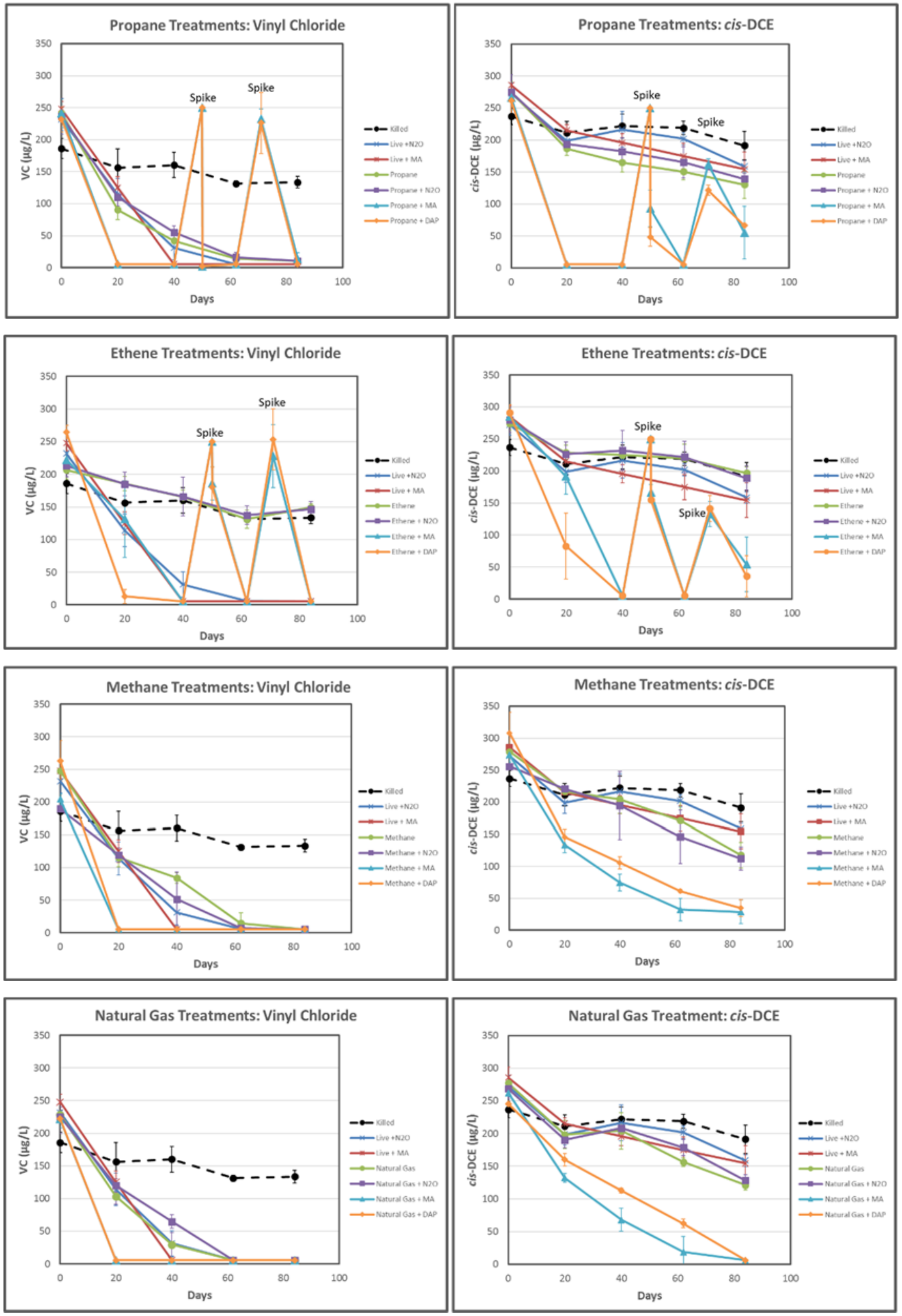


Figure 3.5. Degradation of VC and *cis*-DCE in Microcosm Treatments Amended with Different Gaseous Substrates or No Substrate

These data indicate that while biodegradation of VC occurs without nutrients, the addition of nutrients enhances biological activity in materials collected from the site. Specifically, DAP and the combination of methylamine and TEP were found to be effective nutrient sources, while the combination of N_2O and TEP was not effective at enhancing VC biodegradation, when compared to the live controls (Treatments 2 and 3), and treatments that received substrate gases, but no nutrients (Treatments 4, 7, 10 and 13).

The data show that *cis*-DCE was degraded from between approximately 250 and 300 µg/L, to near or below detection levels (5 µg/L) in the propane, ethene and natural gas treatments that were amended with DAP (Treatments 16, 18 and 19, respectively) and the combination of methylamine and TEP (Treatments 6, 12 and 15, respectively) during the study (**Figure 3.5**). Concentrations of *cis*-DCE decreased to below detection levels within 20 days in the microcosms amended with propane and DAP (Treatment 16) and the combination of methylamine and TEP (Treatment 6). Additionally, an order of magnitude decrease in *cis*-DCE was observed in the treatments amended with methane and these nutrients (Treatments 17 and 9, respectively).

Modest, near linear decreases in *cis*-DCE concentrations were observed in in the remaining microcosms, relative to the killed control (**Figure 3.5**). A 19 percent decrease in *cis*-DCE concentrations was observed in the killed control (Treatment 1), while decreases of 42% and 46% were observed in the live controls that were amended N_2O and TEP (Treatment 2) and methylamine and TEP (Treatment 3), respectively. The decreases observed in the live controls are likely due to biological degradation, as they are significantly greater than the killed controls (which could be attributed to volatile losses during sampling).

Decreases in *cis*-DCE concentrations ranging between 49% and 58% were observed in the propane, methane and natural gas microcosms that did not receive nutrients (Treatments 4, 7 and 13) or that were amended with N_2O and TEP (Treatments 5, 8 and 14), respectively. Decreases in *cis*-DCE concentrations of 28% and 33% were observed in the microcosms with ethene that received no nutrients (Treatment 10) and those amended with N_2O and TEP (Treatment 11), respectively. Interestingly, these decreases were significantly less than the live controls, suggesting that the high concentrations of ethene measured in these treatments throughout the study (**Figure 3.3**) inhibited biodegradation of this compound.

As detailed in Section 3.3.2, propane and ethene treatments containing either methylamine or DAP (Treatments 6, 12, 16, and 18) were spiked two additional times (days 50 and 71) with approximately 250 µg/L *cis*-DCE and VC. As shown in **Figure 3.5**, these compounds were degraded to below detection within 11 days of the first spike (day 61 sampling event), and showed significant degradation 13 days after the second spike (day 84 sampling event). As discussed in Section 3.3.2, substrate gas and nutrient additions ended on day 48 of the study, to evaluate continued biodegradation in the absence of amendment addition. The data collected on days 61 and 84 show that significant degradation of these target compounds was still occurring 36 days after these amendments were last added to the microcosms, although it appears the degradation rates had slowed by the final sampling event.

As was observed with VC, the data from the microcosm testing indicate that while some degradation of *cis*-DCE occurs without nutrient amendments, the addition of nutrients enhances biological activity in materials collected from the site. Specifically, DAP and the combination of methylamine and TEP were found to be effective nutrient sources, while the combination of N_2O and TEP was not effective at enhancing *cis*-DCE biodegradation, when compared to the live controls (Treatments 2 and 3), and treatments that received substrate gases, but no nutrients (Treatments 4, 7, 10 and 13).

The key results of the microcosm study are summarized as follows:

- Biodegradation of the four primary substrate gases (propane, ethene, methane and natural gas) and *cis*-DCE and VC were slower in treatments that did not include DAP or the combination of methylamine and TEP, suggesting a nutrient limitation at the site;
- Complete biodegradation of VC was observed in most live treatments, with the fastest degradation rates being observed in those amended with nutrients (other than N_2O);
- Biodegradation of cis-DCE was considerably faster in the propane- and ethene-amended treatments that received nutrients (other than N_2O);
- Biodegradation of both VC and *cis*-DCE appear to have been inhibited in treatments that exhibited high dissolved concentrations of the four primary substrate gases;
- Biodegradation of VC and *cis*-DCE were sustained for in excess of one month in the absence of amendment addition;
- Methylamine and NH_3 were both shown to be effective gaseous sources of N;
- N_2O and TEP was not an effective combination of nutrients for enhancing biodegradation of alkane/alkene gases or target cVOCs, suggesting that N_2O is not a good source of assimilable N at the site; and
- While a source of N is critical for stimulating biological activity, P does not appear to be a limiting nutrient. This suggests that the addition of TEP will not be required during the field demonstration.

3.4 BATCH KINETIC STUDIES & MODELING

Based on degradation of cVOCs in microcosms that received propane or ethene as growth substrates (discussed in in Section 3.1), experiments to quantify cVOC degradation kinetics were prepared using cultures enriched from microcosms on these individual substrates.

3.4.1 Enrichment Set Up

Microbial enrichments using either propane or ethene as growth substrates were sourced from microcosm Treatment 6 and 12, respectively. Enrichments were prepared by removing 0.5 mL of liquid from the microcosms using a sterile syringe and 20 gauge needle, and adding the liquid into 75 mL sterile Basal Salts Medium (BSM) (Hareland et al., 1975). Propane and ethene gases were each passed through a sterile filter to yield 3% (v/v) in bottle headspace as the primary growth substrate, with the balance of the headspace comprised of sterile-filtered room air. In addition, 10 mg/L of sterile methylamine (as a 40% solution) was provided into the medium. Once cultures grew turbid, they were passed in a 1/100 ratio into fresh medium. After three passes, the cultures were screened for their ability to degrade the compounds of concern (*cis*-DCE, VC), and used to estimate Michaelis-Menten kinetic parameters including potential inhibition terms as described further below. The propane enrichments were observed to grow significantly faster than the ethane enrichments during each of the passes.

3.4.2 Enrichment Batch Kinetic Studies

Mixed enrichment cultures were grown as explained above with 3% (v/v) propane or ethene to mid log phase (OD_{600} of 0.2 to 0.6), washed via centrifugation, and either concentrated or diluted to ODs ranging from 0.05 to 0.2. Batch experiments were prepared using 60 mL clear glass serum bottles with 30 mL of prepared culture and 30 mL initial headspace volume (air, with or without propane or ethene), sealed with Teflon-lined septa, and aluminum crimp seals. Bottles were placed on an orbital shaker at 200 rpm at room temperature (~22˚C). Headspace samples were analyzed as a function of time to determine changes in *cis*-DCE, VC, propane, or ethene concentrations. Propane, ethene, *cis*-DCE and VC concentrations were determined via headspace analysis using a GC-FID.

Batch kinetic testing was performed utilizing combinations of substrate (propane or ethene), and *cis*-DCE or VC. These experiments focused on quantifying substrate, *cis*-DCE, and VC biodegradation kinetics. Data from these experiments were used to estimate maximum degradation rate coefficients and the half saturation parameters for propane, ethene, *cis*-DCE, and VC by propane and ethene-consuming enrichment cultures as described in Section 3.4.3.

3.4.3 Enrichment Batch Kinetic Results

Results from the batch kinetic studies are presented in **Figure 3.6** and **Figure 3.7**, together with modeled concentrations as described below.

The utilization of substrate (propane or ethene) and co-metabolic degradation of VC and *cis*-DCE were modeled assuming Michaelis-Menten kinetics with no oxygen or nutrient limitations. Cell densities were observed either before or after the short term kinetic experiments and were assumed to be constant during the individual experiments. Competitive inhibition of alkane/alkene gas upon cVOC degradation was assumed to be the dominant inhibition mechanism. The modeling was performed using the following equations describing alkane/alkene gas and cVOC changes with time:

$$\frac{dC_{VOC}}{dt} = \frac{XV_{max,VOC}C_{VOC}}{C_{VOC}+K_{S,VOC}\left(1+\frac{C_{ALK}}{K_{I,ALK}}\right)} \qquad \text{Eq. 1}$$

$$\frac{dC_{ALK}}{dt} = \frac{XV_{max,ALK}C_{ALK}}{C_{ALK}+K_{S,ALK}} \qquad \text{Eq. 2}$$

where C_{VOC} and C_{ALK} are the cVOC and alkane/alkene concentrations, t is time, X is the cell density or concentration, $V_{max,VOC}$ and $V_{max,ALK}$ are the maximum degradation rate coefficients for cVOC and alkane/alkene, and $K_{S,VOC}$ and $K_{S,ALK}$ are the half saturation parameters. $K_{I,ALK}$ is an inhibition constant that was assumed to be the same as $K_{S,ALK}$. This assumption that the inhibition coefficient can be approximated by the half saturation coefficient has been employed in previous co-metabolic studies using short-chain hydrocarbons (Strand et al., 1990). Note that Eq. 1 assumes that cVOC degradation is inhibited by the presence of alkane/alkene gas, but Eq. 2 assumes that inhibition by cVOC on alkane/alkene gas utilization is negligible. Equilibrium between headspace gas and aqueous phase was assumed at each time point using appropriate dimensionless Henry's constants (C_{gas}/C_{aq}), taken as 24.82, 7.95, 0.96, and 0.15 for propane, ethene, VC, and *cis*-DCE respectively.

Degradation of all compounds was evident as shown in **Figure 3.6** and **Figure 3.7**, but degradation of *cis*-DCE was clearly slowest. Slower relative degradation rates (i.e., rates relative to concentration) at higher concentrations were observed for propane and VC in the absence of propane (i.e., with no inhibition) in the propane enrichment, and for ethene in the ethene enrichment. This provides evidence that concentrations observed were near the K_S or greater. With Michaelis-Menten models, when concentrations are significantly smaller than K_S, relative rates approach a constant value of V_{max}/K_S.

Michaelis-Menten parameters were estimated using the model and a nonlinear least-square analysis similar to that described by Smith et al. (1998). The summation of the square of relative errors between observed and modeled concentrations was minimized using the Solver function of Microsoft Excel®, and initial concentrations, K_S, and the ratio of V_{max}/K_S were fitted. The ratio V_{max}/K_S was utilized rather than V_{max} because the two kinetic parameters can be highly correlated at concentrations below K_s as noted by Smith et al. (1998), potentially leading to underestimation of parameter uncertainty. Parameters for propane and ethene utilization were estimated first, and given modeled behavior of these substrates, parameters describing VC and *cis*-DCE degradation were estimated subsequently. Values for K_s for *cis*-DCE in the propane enrichment, and VC and *cis*-DCE in the ethene enrichment were estimated to be greater than 100 g/L. These excessive values are not meaningful, but this does indicate that relative rates (without inhibition) approached a first order constant value (represented by V_{max}/K_S).

Regression of the model parameters V_{max} and K_S for the data in **Figure 3.6** and **Figure 3.7** resulted in the estimated parameter values shown in **Table 3.2** and **Table 3.3**. The curves shown in **Figure 3.6** and **Figure 3.7** represent the model, and provide reasonable descriptions of the data. This includes the assumption that relative inhibition of cVOCs by propane and ethene, as given by $K_{I,ALK}$ in Equation 1, can be represented by $K_{S,ALK}$, as $K_{I,ALK}$ was not adjusted during fitting of the cVOC degradation.

The estimated model parameters can be used to predict and compare cVOC degradation using propane and ethene. This assumes that enrichments are representative of microbial communities that will be stimulated in the field by addition of the given substrate. **Figure 3.8** shows the evolution of substrate and cVOCs with initial concentrations of 2,000 µg/L substrate, 25 µg/L VC, 150 µg/L *cis*-DCE, with the assumption of no cell growth (at equivalent optical densities), and no separate gas phase. While degradation performance of both the propane and ethene enrichments were generally similar, with clear effects of substrate inhibition over a broad range of concentrations, this impact was most notable in examining *cis*-DCE degradation. Inhibition of VC was less and consumption of propane itself appeared slightly quicker in the propane enrichment. This observation, together with faster observed growth of propane enrichments, suggests that propane may be preferable for implementation at field scale for degradation of VC and *cis*-DCE. Modeling similar to that above using the parameters given in **Table 3.2** may be further used during design and operation of the field scale system.

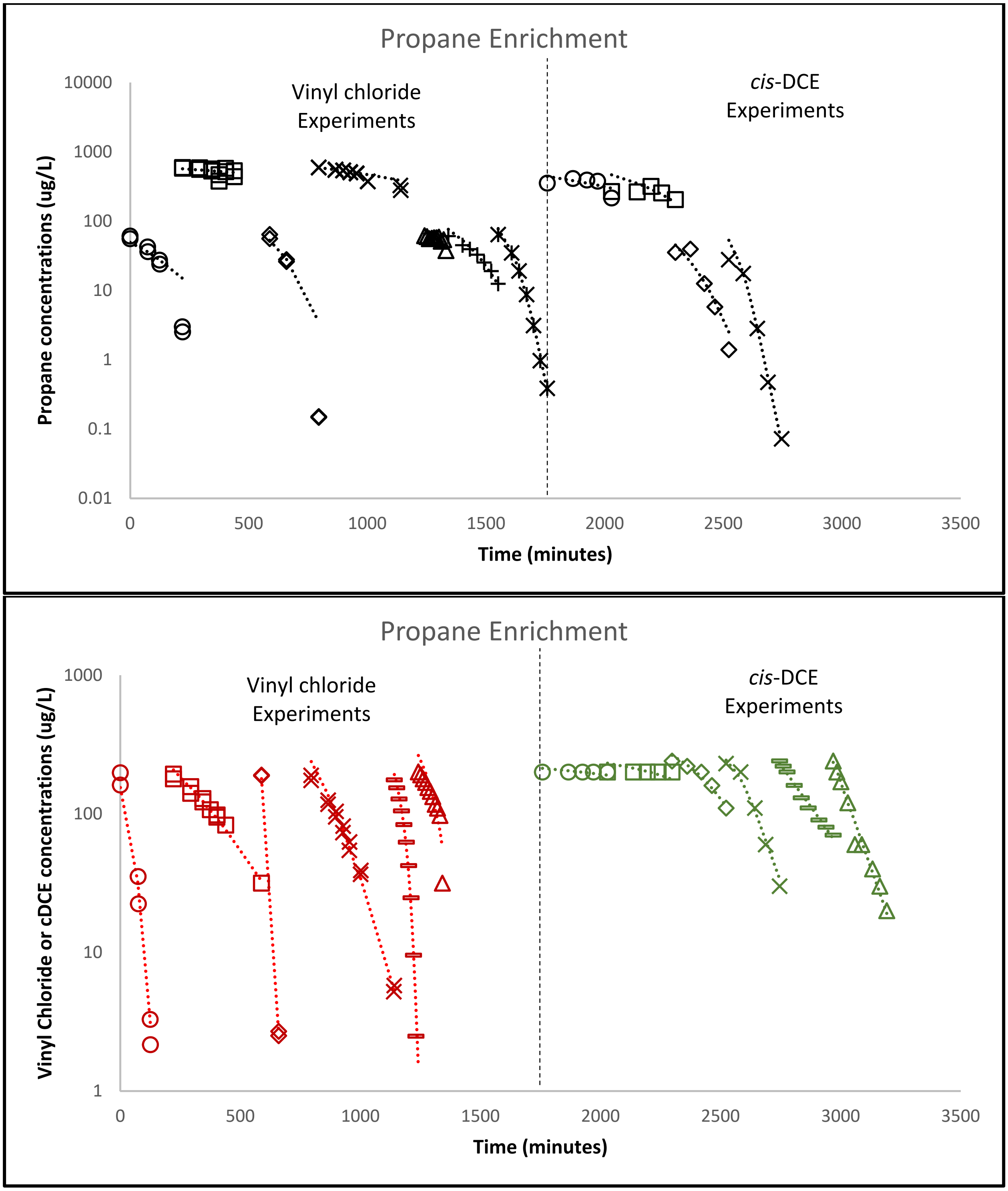


Figure 3.6. Utilization of Propane and Degradation of VC and *cis*-DCE in the Batch Kinetic Experiments. All indicated samples are individual measurements of multiple experiments and the time axis was adjusted to offset the individual experiments for great visual clarity. Dotted lines indicate modeled concentrations using fitted initial concentrations, and the parameters provided in **Table 3.2**. Black data at top indicate propane concentrations, red data indicate VC, and green data indicate *cis*-DCE.

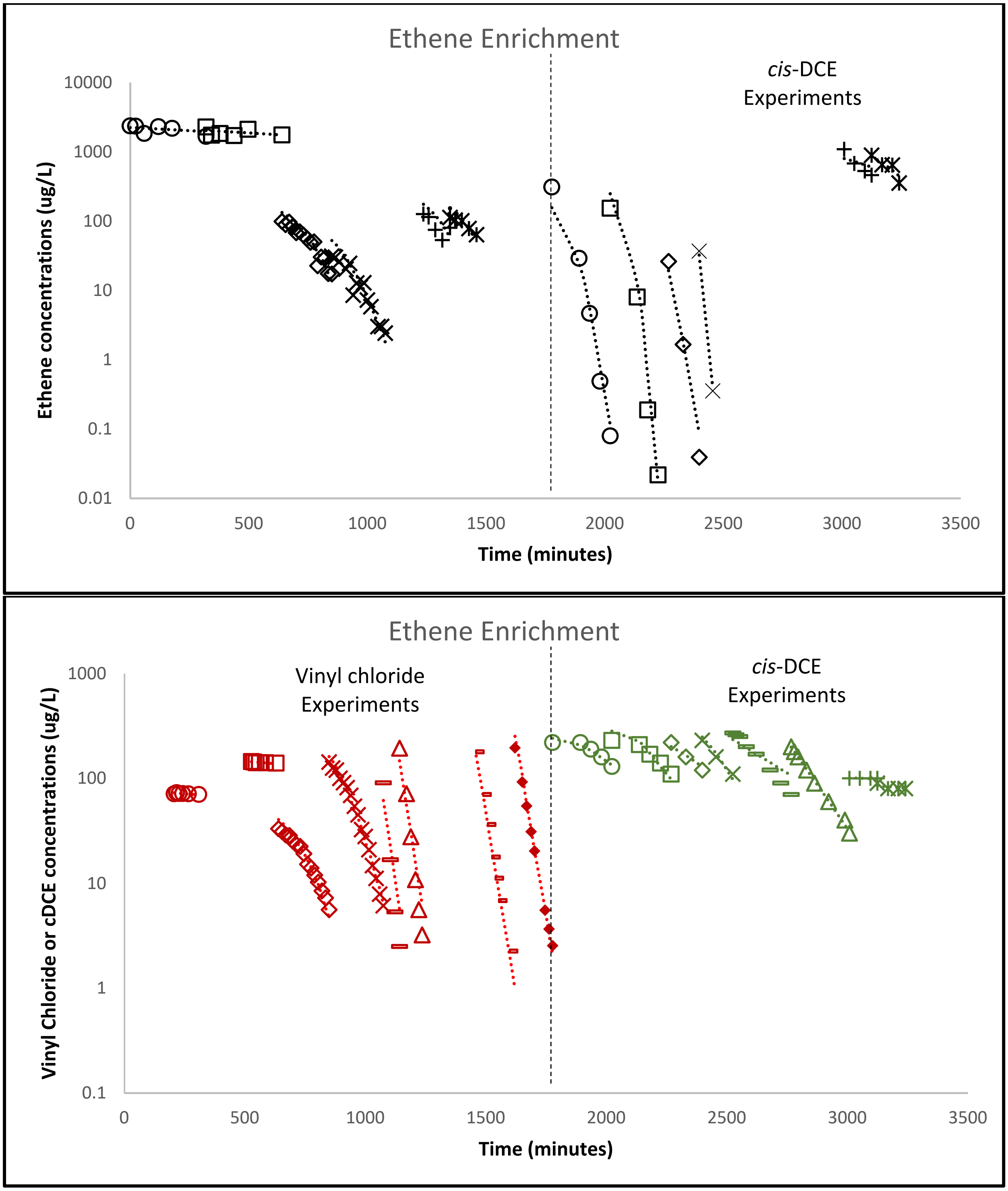


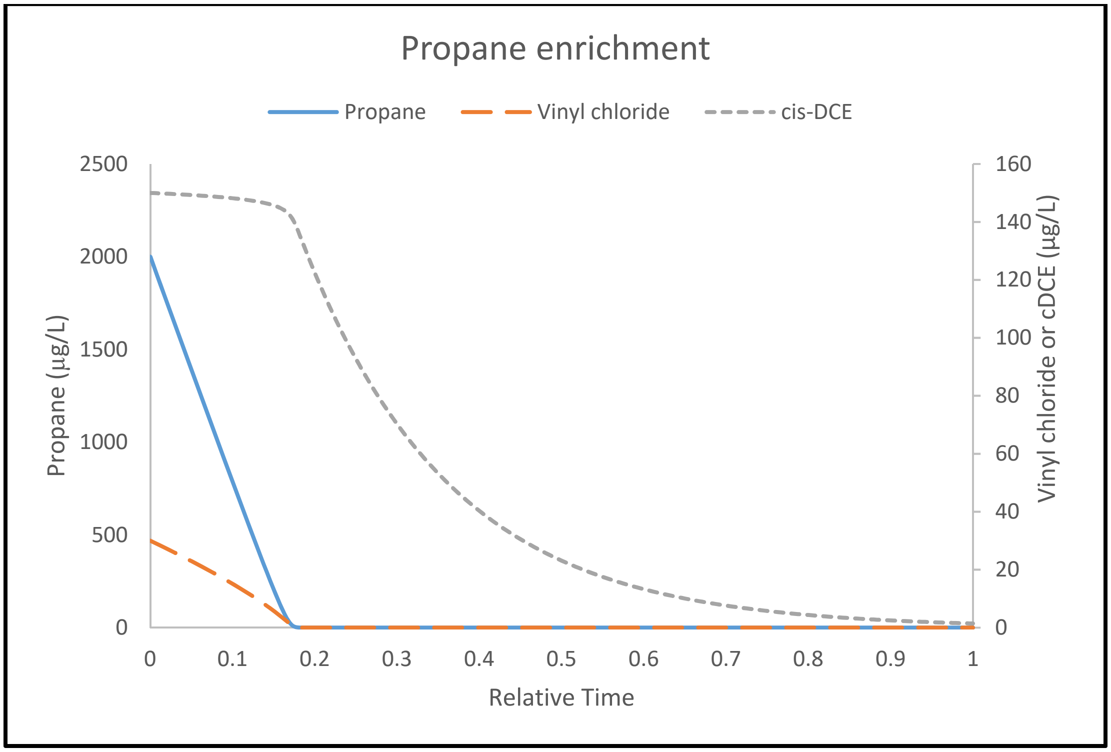
Figure 3.7. Utilization of Ethene and Degradation of VC and *cis*-DCE in the Batch Kinetic Experiments. All indicated samples are individual measurements of multiple experiments and the time axis was adjusted to offset the individual experiments for great visual clarity. Dotted lines indicate modeled concentrations using fitted initial concentrations, and the parameters provided in **Table 3.3**. Black data at top indicate ethene concentrations, red data indicate VC, and green data indicate *cis*-DCE.

Table 3.2. Regressed Kinetic Model Parameters for the Propane Enrichment. The propane inhibition coefficient for VC and *cis*-DCE degradation was assumed equal to $K_{s,pro}$.

Parameter	Units	Regressed Value
Propane		
-$K_{S,pro}$	$\mu g\ L^{-1}$	30.0 ± 6.4
-$V_{max,pro}/K_{S,pro}$	$OD^{-1}\ hr^{-1}$	9.6 ± 0.8
-$V_{max,pro}$	$\mu g\ L^{-1}\ OD^{-1}\ hr^{-1}$	290 ± 70
Vinyl chloride		
-$K_{S,VC}$	$\mu g\ L^{-1}$	33.5 ± 2.7
-$V_{max,VC}/K_{S,VC}$	$OD^{-1}\ hr^{-1}$	7.2 ± 0.3
-$V_{max,eth}$	$\mu g\ L^{-1}\ OD^{-1}\ hr^{-1}$	240 ± 20
cis-DCE		
-$K_{S,DCE}$	$\mu g\ L^{-1}$	-
-$V_{max,DCE}/K_{S,DCE}$	$OD^{-1}\ hr^{-1}$	0.13 ± 0.02
-$V_{max,DCE}$	$\mu g\ L^{-1}\ OD^{-1}\ hr^{-1}$	-

Table 3.3. Regressed Kinetic Model Parameters for the Ethene Enrichment. The ethene inhibition coefficient for VC and *cis*-DCE degradation was assumed equal to $K_{s,eth}$.

Parameter	Units	Regressed Value
Ethene		
-$K_{S,eth}$	$\mu g\ L^{-1}$	39.0 ± 1.5
-$V_{max,eth}/K_{S,eth}$	$OD^{-1}\ hr^{-1}$	5.0 ± 0.2
-$V_{max,eth}$	$\mu g\ L^{-1}\ OD^{-1}\ hr^{-1}$	200 ± 10
Vinyl chloride		
-$K_{S,VC}$	$\mu g\ L^{-1}$	-
-$V_{max,VC}/K_{S,VC}$	$OD^{-1}\ hr^{-1}$	1.06 ± 0.03
-$V_{max,eth}$	$\mu g\ L^{-1}\ OD^{-1}\ hr^{-1}$	-
cis-DCE		
-$K_{S,DCE}$	$\mu g\ L^{-1}$	-
-$V_{max,DCE}/K_{S,DCE}$	$OD^{-1}\ hr^{-1}$	0.054 ± 0.013
-$V_{max,DCE}$	$\mu g\ L^{-1}\ OD^{-1}\ hr^{-1}$	-



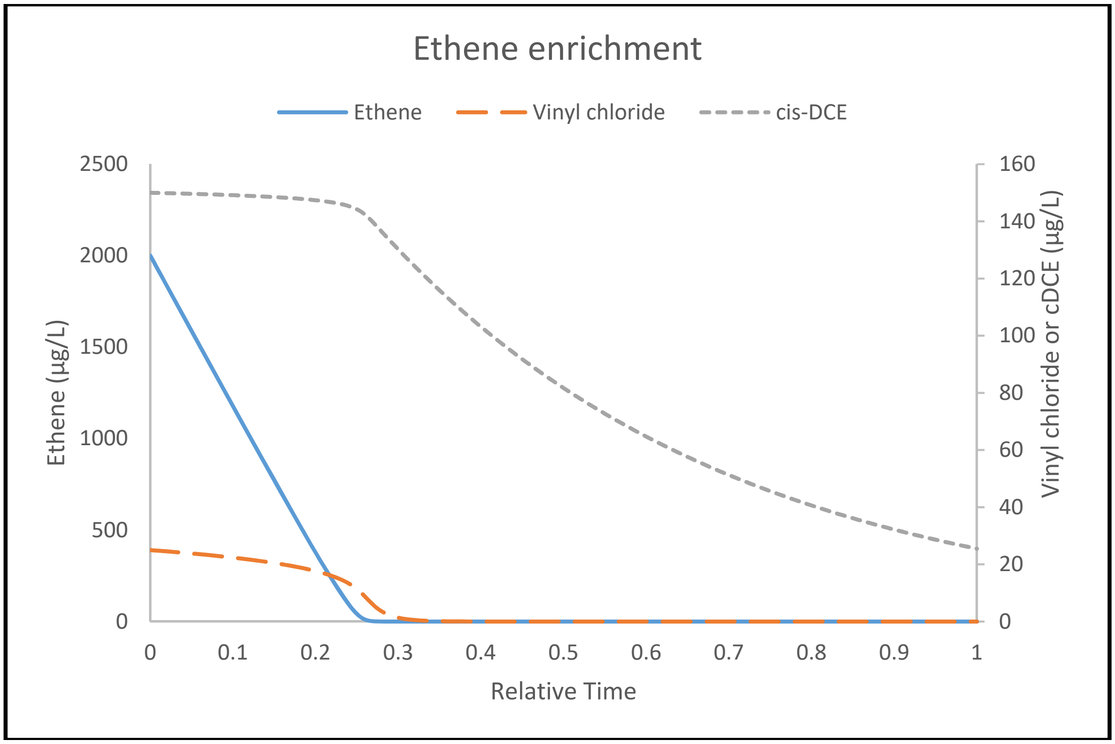


Figure 3.8. Modeled Propane, Ethene, VC, and *cis*-DCE Evolution with Time for a Hypothetical Scenario. The scenario assume no bacterial growth (with both enrichments at equivalent optical densities), no separate gas phase, and initial concentrations of 2,000 µg/L for propane or ethene, 25 µg/L for VC, and 150 µg/L for *cis*-DCE.

4.0 SITE CHARACTERIZATION ACTIVITIES AND RESULTS

As discussed in Section 1.0, the site selected for this demonstration is the Building 324 plume at former MBAFB (**Figure 1.1**). While existing site characterization data were evaluated, additional site assessment was necessary to more accurately delineate groundwater contamination within the proposed treatment area, and to develop the site hydrogeological conceptual model needed for biosparging well and system design. These activities included a direct-push investigation, sparge well and monitoring well installations, and sparge testing. The following site characterization activities were performed between August and November of 2017:

- Advancement of 8 direct-push borings for hydraulic profiling and collection of 28 discrete groundwater samples using Geoprobe's® HPT-Groundwater sampling tool;
- Collection of two direct-push continuous soil cores;
- Installation of two vertical sparge testing wells;
- Installation of 12 discrete interval monitoring wells;
- Installation of 6 vapor probes; and
- Two rounds of sparge testing

4.1 DIRECT-PUSH INVESTIGATION

Groundwater cVOC data collected during direct-push investigation activities were used to assess the subsurface lithology and horizontal and vertical extent of contaminants along the proposed treatment barrier shown in **Figure 4.1**. A total of eight HPT-Groundwater sampling borings were advanced along a transect perpendicular to groundwater flow until groundwater concentrations of *cis*-DCE and VC (the contaminants of concern at the Site) above Federal MCLs were fully delineated. **Figure 4.2** presents a generalized geologic cross section with contaminant distribution within the demonstration area that was developed using data collected from the continuous soil cores, the HPT borings, and the discrete groundwater samples. These data indicate that the plume of groundwater concentrations exceeding MCLs is approximately 210 ft wide, and between approximately 5 and 15 ft thick. The plume is located within a sand and shell hash layer and a dense sand layer, that is located directly above a low permeability clay layer (present between approximately 34 and 42 ft-bgs). There were no observed exceedances of MCLs in any of the samples collected below the clay unit. Direct-push investigation activities and results will be presented in more detail in the Demonstration Work Plan.

4.2 SPARGE WELL AND MONITORING WELL INSTALLATIONS

As shown in **Figures 4.3** and **4.4**, two vertical gas sparge testing wells (STWs), 12 discrete interval performance monitoring wells (PMWs), and 6 vapor probes (VP-1 through VP-6) were installed within the demonstration area. All wells were installed using direct-push drilling methods. This group of wells and vapor probes was located near the center of the groundwater plume, and immediately downgradient of the proposed biobarrier.

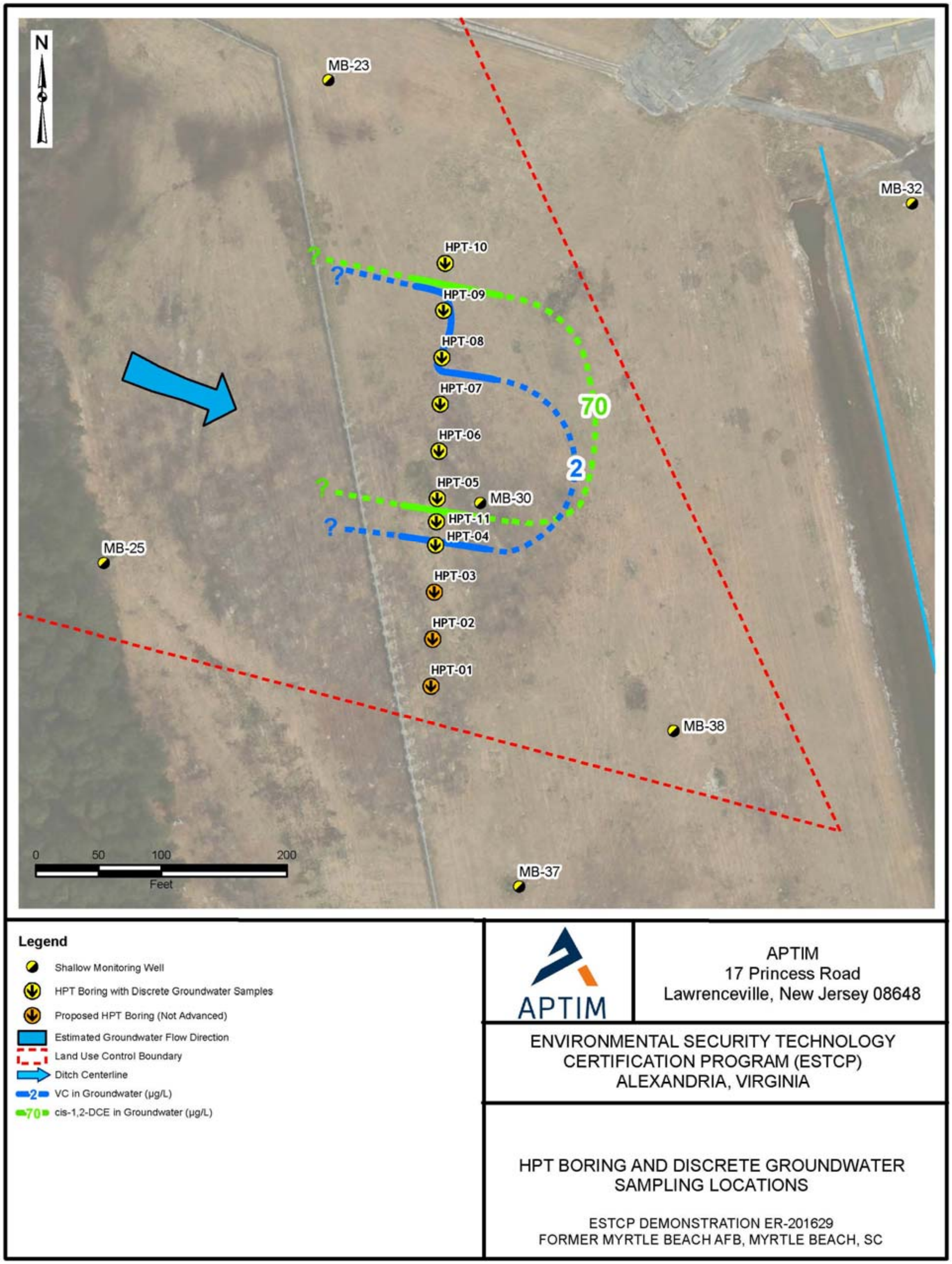


Figure 4.1. HPT Boring and Discrete Groundwater Sampling Locations

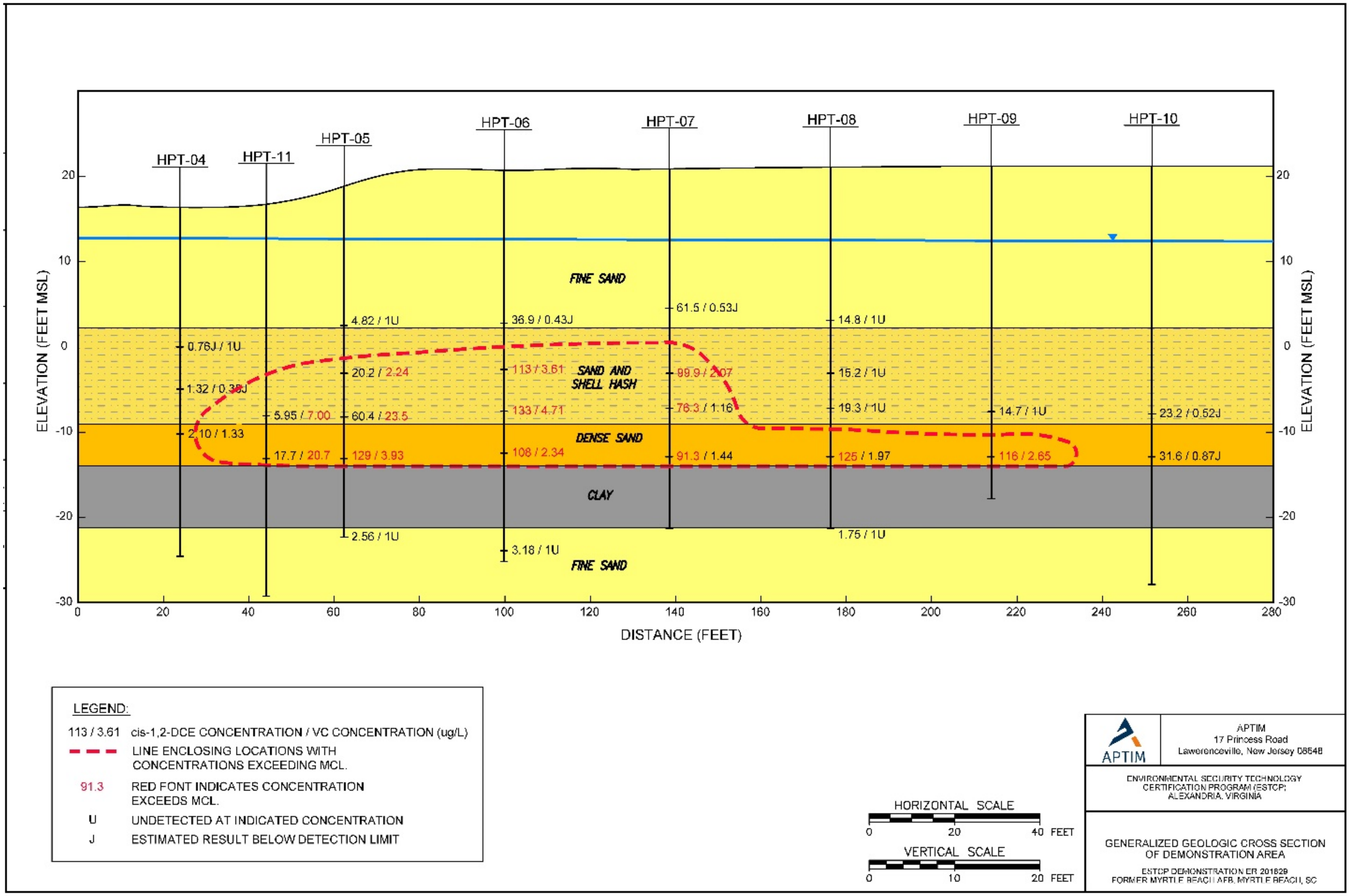


Figure 4.2. Generalized Geologic Cross Section. Data presented include cis-DCE and VC concentrations measured in the 28 discrete groundwater samples that were collected during advancement of 8 HPT borings. Concentrations exceeding MCLs are enclosed by the dashed red line.

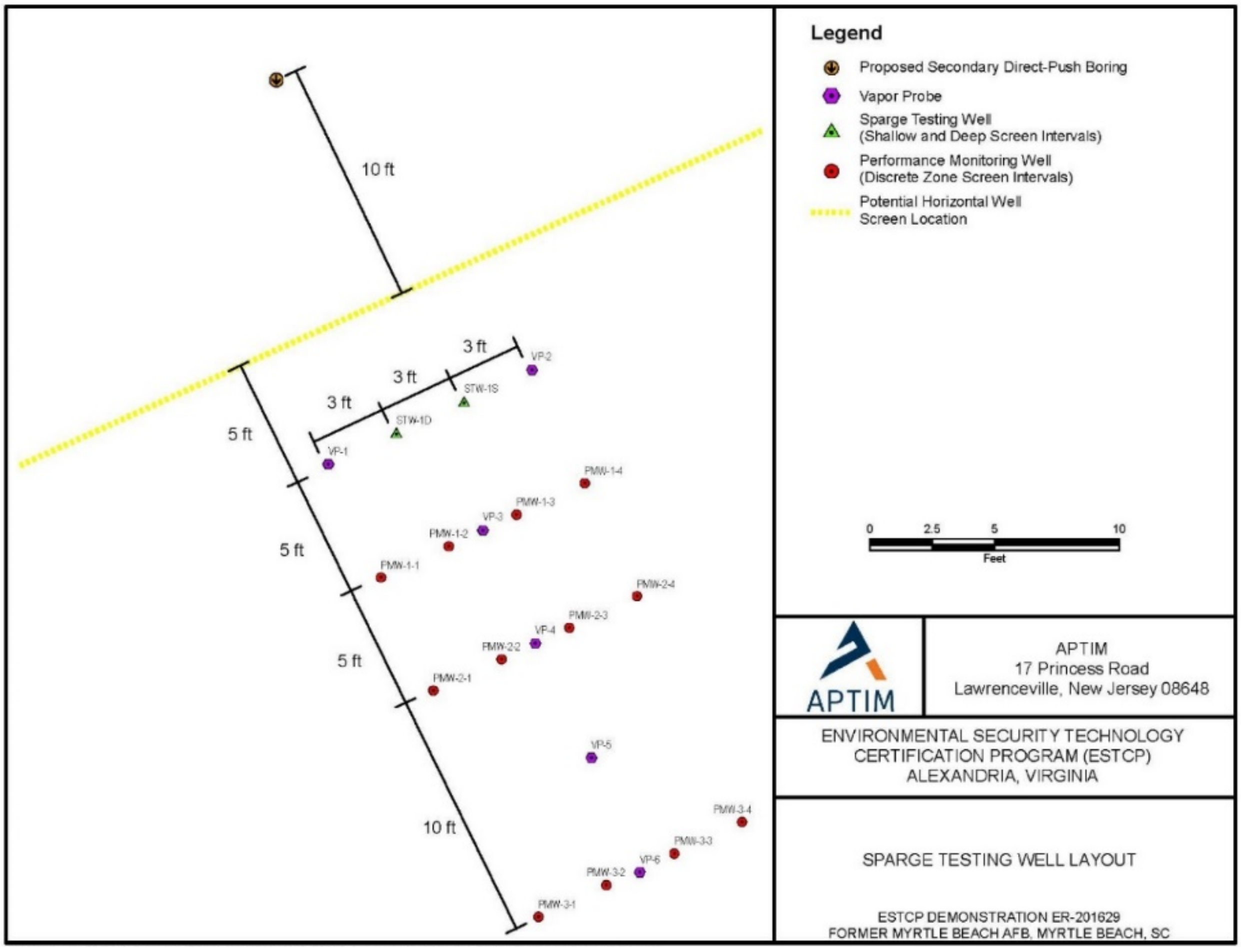


Figure 4.3. Sparge Testing Well Layout

The shallow and deep STWs (STW-1S and STW-1D) were installed within adjacent boreholes (~ 3 feet apart), as shown in **Figures 4.3** and **4.4**. These 1.25-inch diameter wells were constructed with 2-foot long pre-packed screens installed at two different vertical intervals; one in the approximate middle of the plume within the sand and shell hash layer, and one at the bottom of the plume within the dense sand layer. Four discrete interval PMWs, each 1.25-inch in diameter with 3-foot long pre-packed screens, were installed adjacent to each other in three clusters (each in a line, spaced ~3 feet apart). The clusters are located approximately 5 ft, 10 ft, and 20 ft downgradient from the sparge wells (see **Figures 4.3** and **4.3**). The location of the PMW screens allowed for the monitoring of four discrete vertical groundwater depths at each cluster location. Vertical and horizontal distribution of these wells was designed to allow for a detailed assessment of gas distribution within the dense sand and shell hash layers during sparge testing. Three of the four wells in each cluster span the vertical extent of the plume identified during the direct-push investigation (as identified by the red dashed line on **Figure 4.4**). The fourth well is screened immediately above the plume. There is approximately two feet of vertical spacing between screen intervals at each well cluster. Well and vapor probe installation activities will be presented in more detail in the Demonstration Work Plan.

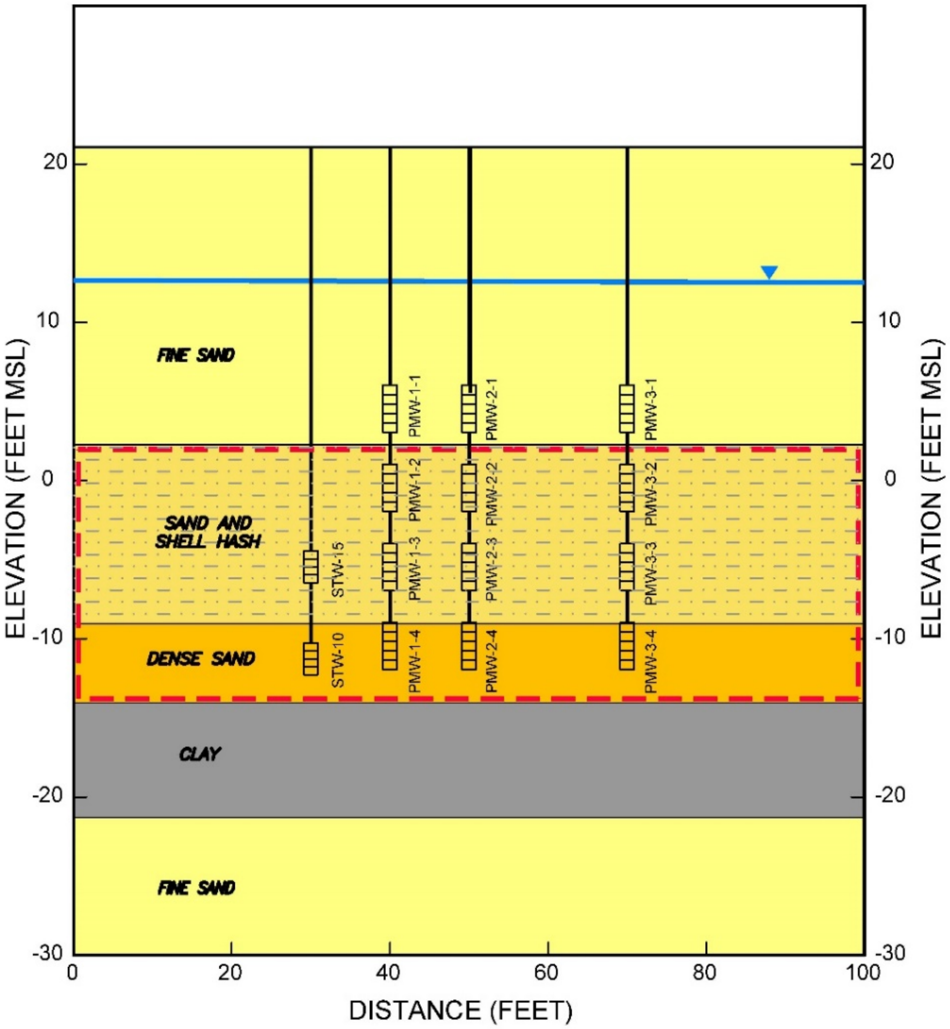


Figure 4.4. Cross Section of Sparge Testing Well Layout. The layout includes two sparge testing wells (STW-1S and STW-1D) and three rows of monitoring wells (PMW designations) located 5’, 10’ and 20’ from the sparge wells.

4.3 SPARGE TESTING

The first round of sparge testing was performed on October 10, 2017, with subsequent testing performed on November 15 and 16, 2017. A total of eight sparge tests were performed over these 3 days. Sparging was performed at shallow sparge well STW-1S and deep sparge well STW-1D, as well as monitoring wells PMW-2-2 and PMW-2-3 (**Figures 4.3** and **4.4**). During all of the sparge tests, pure oxygen and pure helium were sparged simultaneously into the test well. Helium was added at a target concentration of approximately 10 percent of the total gas injection flow during most of the tests. However, helium was added at higher percentages during testing at lower total flow rates, and at lower percentages during testing at higher total flow rates, due to the limited measurement range of the helium mass flow meter.

As summarized in **Table 4.1**, two sparge tests involved sparging at continuous rates, two sparge tests involved pulsing of the sparge gases, and four tests involved increasing the flow rate in a step-wise fashion. The duration of individual sparge tests ranged from 38 to 107 minutes, with combined oxygen and helium sparge rates between 0.75 and 10.5 cubic feet per minute (CFM). The two pulse sparge tests involved short (10-20 minute) intermittent pulses at deep sparge well PMW-1D to evaluate the potential effects of pulsing at different flow rates on the aquifer. A total of 2,034 cubic feet (169 lbs.) of oxygen and 214 cubic feet (2.36 lbs.) of helium were injected during the eight tests.

The 12 newly installed performance monitoring wells (**Figures 4.3** and **4.4**) and nearby existing monitoring well MB-30 were monitored in the field for dissolved oxygen (DO) and groundwater elevation prior to (baseline) and during sparging to determine the horizontal and vertical influence of the oxygen sparging. DO concentrations were measured via a combination of dedicated and non-dedicated DO meters. Groundwater elevations were measured manually at all of the wells during all eight tests, and continuously at select wells using dedicated transducers during testing on November 15 and 16, 2017. Vapor samples were periodically collected in Tedlar bags from the six vadose zone vapor probes using a vacuum pump. These samples were analyzed in the field for helium using a handheld helium gas detector, as well as for cVOCs, oxygen, hydrogen sulfide, carbon monoxide, and percent of the lower explosive limit (LEL) using a portable handheld multi-gas detector to determine if sparged gases were reaching or impacting the vadose zone. Periodic direct readings for the gases listed above were also collected from the headspace of select monitoring wells during testing on November 16, 2017.

The first sparge test was performed at deep sparge well STW-1D to determine the horizontal and vertical distribution of oxygen while sparging at the bottom of the plume. This sparge well is screened at the bottom of the dense sand layer, with the top of the screen located approximately 3 feet below the bottom of the shell hash layer (**Figure 4.4**). The total depth of this well is comparable to that of the horizontal well that was originally proposed for installation at the bottom of the plume (e.g., immediately above the Clay unit). As summarized in **Table 4.1**, a two-step sparge test with combined flow rates of 2.8 CFM (step 1) and 5.6 CFM (step 2) was conducted at STW-1D. Based on the high permeability and hydraulic conductivities of these two lithologic layers (between ~80 and 100 ft/day) estimated during site characterization activities (e.g., HPT borings), it was anticipated that significant upward distribution of sparged gases (>10 feet) would be observed after sparing for a few minutes. However, increases in DO concentrations were only observed in the closest monitoring well (PMW-1-4, also screened within the dense sand layer) located 5’ away, and the two wells screened within the deepest portion of the shell hash layer (PMW-1-3 and PMW-2-3, located 5’ and 10’ away). Increases in DO concentrations were not observed in any of the monitoring wells screened within the middle or upper portions of the shell hash layer (screened ~10’ and 15’ above the deep sparge well). A small temporal increase in DO concentrations was measured in shallow sparge well STW-1S, which is located 3’ away from the deep sparge well and is screened ~5’ above the sparging interval.

Table 4.1. Summary of Sparge Testing Parameters

Date	Sparge Well	Oxygen Sparge Rate (SCFM)	Helium Sparge Rate (SCFM)	Combined Sparge Rate (SCFM)	Percent Helium	Duration (minutes)	Oxygen Sparged (cubic ft.)	Oxygen Sparged (lb.)	Helium Sparged (cubic ft.)	Helium Sparged (lb.)
STW-1D Step Test										
10/10/2017	STW-1D	2.5	0.3	2.8	11	63	158	13.1	18.9	0.21
10/10/2017	STW-1D	5.0	0.6	5.6	11	18	90	7.5	10.8	0.12
STW-1S Step Test										
10/10/2017	STW-1S	2.5	0.25	2.75	9	49	123	10.2	12.3	0.13
10/10/2017	STW-1S	5.0	0.6	5.6	11	35	175	14.5	21.0	0.23
STW-1D Constant Rate Test										
11/15/2017	STW-1D	0.5	0.25	0.75	33	76	38	3.2	19.0	0.21
STW-1D Pulse Test										
11/15/2017	STW-1D	0.5	0.25	0.75	33	15	7.5	0.6	3.8	0.04
11/15/2017	STW-1D	0.5	0.25	0.75	33	10	5.0	0.4	2.5	0.03
11/15/2017	STW-1D	0.5	0.25	0.75	33	10	5.0	0.4	2.5	0.03
STW-1D Step Test										
11/15/2017	STW-1D	1.0	0.15	1.15	13	68	68	5.6	10.2	0.11
11/15/2017	STW-1D	5.0	0.5	5.5	9	39	195	16.2	19.5	0.21
PMW-2-3 Step Test										
11/16/2017	PMW-2-3	2.0	0.25	2.25	11	67	134	11.1	16.8	0.18
11/16/2017	PMW-2-3	5.0	0.5	5.5	9	40	200	16.6	20.0	0.22
STW-1D Pulse Test										
11/16/2017	STW-1D	10.0	0.5	10.5	5	18	180	14.9	9.0	0.10
11/16/2017	STW-1D	10.0	0.5	10.5	5	20	200	16.6	10.0	0.11
PMW-2-2 Constant Rate Test*										
11/16/2017	PMW-2-2	6.0	0.5	6.5	8	43	258	21.4	21.5	0.24
11/16/2017	PMW-2-2	6.0	0.5	6.5	8	33	198	16.4	16.5	0.18
					Totals	**604**	**2034**	**169**	**214**	**2.36**

Note:

* Constant rate sparging at PMW-2-2 was interrupted for 5 minutes during oxygen cylinder change out.

Based on the limited vertical distribution of dissolved oxygen observed during the first sparge test, a subsequent sparge test was performed at shallow sparge well STW-1S. As summarized in **Table 4.1**, a two-step sparge test with combined flow rates of 2.75 CFM (step 1) and 5.6 CFM (step 2) was conducted. Results from this test showed increases in DO concentrations at wells PMW-1-3 and PMW-1-4, both located 5' away. As shown on **Figure 4.4**, well PMW-1-3 is screened at the same approximate depth as the shallow sparge well (near the bottom of the shell hash layer), while PMW-1-4 is screened 5' deeper (within the dense sand layer).

Increases in water levels were observed immediately after the initiation of sparging during both of the tests, indicating hydraulic connection within the test zone. However, groundwater mounding was generally greater at wells that were screened in the same interval as the sparge wells, compared to shallower wells that were the same distance away. Detections of helium and/or significant changes to the vadose zone gas composition were not observed in any of the vapor probe samples collected during sparge testing, indicating that sparged gases were not reaching the vadose zone. Observed gas flow breakout and operational pressures were below 12 psi, which is significantly below the overburden pressure, and optimal for the design and operation of the biosparging system.

The data collected during these two tests suggested that, while exhibiting high horizontal hydraulic conductivity, the Shell Hash layer has a much lower (probably orders of magnitude) vertical hydraulic conductivity, and is extremely anisotropic. Subsequent testing performed on November 15 and 16, 2017 at multiple wells (see **Table 4.1**) confirmed this to be the case, and indicated that sparging at rates of approximately 6.5 to 10 CFM provides a horizontal area of influence of at least 10 feet (although no increase in vertical gas distribution was observed). The reason for the vertical anisotropy is likely the composition of the Shell Hash layer, which consists of approximately 20-30% small (typically <3 mm) shell fragments. Most of these shell fragments were likely deposited in the horizontal position, creating bedding-like features that significantly reduce the vertical distribution of gasses during sparging, as observed during our testing.

5.0 GO/NO GO DECISION

Completion of treatability testing marks a Go/No Go decision point for this project. The microcosm data clearly shows that the addition of propane or ethene plus nutrients stimulates rapid degradation of the target contaminants at the demonstration site. Modeling of the batch kinetic testing data indicates that, while degradation performance of both the propane and ethene enrichments were generally similar, somewhat less substrate inhibition of cis-DCE degradation was observed using propane. Inhibition of VC was less than *cis*-DCE for both enrichments, and consumption of propane itself appeared slightly quicker in the propane enrichment. These observations, together with the faster observed growth of propane enrichments, suggests that propane is preferable for implementation at field scale for degradation of VC and *cis*-DCE.

While the vertical anisotropy of the sand and shell hash layer observed during sparge testing is not ideal for the use of horizontal biosparging wells (which work best when sparged gases are easily distributed in the upward vertical direction), the sparge testing data indicate that sparging at 3 different vertical intervals would distribute gases sufficiently throughout the 15 ft plume thickness. Additionally, based on the observed area of influence during sparge testing, it is estimated that vertical biosparging wells located on 20-foot centers would provide sufficient horizontal gas distribution within the aquifer. Based on these findings, three alternatives to create a cometabolic sparging biobarrier that would span the entire cross-sectional area of the plume (as shown in **Figures 4.1** and **4.2**) were evaluated:

1. The installation of 3 horizontal bisparging wells at different depths throughout the thickness of the plume;
2. The installation of one horizontal biosparging well at the bottom of the plume, and 16 vertical biosparging wells at two separate vertical intervals within the shell hash layer, and;
3. Installation of 22 vertical biosparging wells at three separate vertical intervals throughout the thickness of the plume.

The evaluation of these alternatives included estimated costs, as well as impacts on the biosparging system design and operation. The drilling costs associated with Alternative #1 were the highest by far of the three alternatives, and this approach was eliminated as a potential cost-effective option. While Alternative #2 is a potentially cost-effective option, the well installation costs are approximately $50K higher than Alternative #3, while seemingly providing no additional benefit relating to gas distribution in the subsurface or biosparging system design and operation flexibility. Alternative #3 was determined to have the lowest cost associated with biosparging well installations, with the added advantage of the direct-push drilling methods not generating drill cuttings that would require off-site disposal. Furthermore, the use of 22 vertical biosparging wells allows for sparging at a single well at a time, and cycling through the wells over the course of hours, or even days. With an estimated flow rate of 10-15 CFM per well, the required instantaneous flow rates of the sparged gases for a single vertical biosparging well will be considerably lower than that required by a single horizontal biosparging well with a long screen interval (~50-60 CFM). It was estimated that this reduced instantaneous flow rate will minimize the size and cost of some of the off-grid biosparging system components. Additionally, the use of vertical bioparging wells will create a wider treatment biobarrier than what would be expected using horizontal biosparging wells, thus providing additional residence time for treatment of target contaminants. For the above reasons, Alternative #3 was chosen as the optimal sparging approach to provide cost-effective distribution of gaseous amendments for cometabolic treatment of target cVOCs at this site, while also providing significant biosparging system operational flexibility.

The choice to use vertical biosparging wells instead of horizontal biosparging wells during this demonstration was based primarily on results of the site characterization data (mostly sparge testing results), and is not intended to suggest that horizontal biosparging wells could not be effective at distributing gases in hydrogeologic settings that are not as unique (e.g., high vertical anisotropy) as those encountered at this site. To the contrary, horizontal wells have been used successfully for air sparging/soil vapor extraction and biosparging in a wide range of hydrogeologic environments.

Based on the success of the microcosm studies, and the demonstrated ability to distribute gaseous amendments using vertical wells, we are proposing that we move forward with the field demonstration at the MBAFB Building 324 Plume using vertical biosparging wells, as described in Alternative #3. A summary of the proposed field demonstration design is provided in the following section.

6.0 PRELIMINARY FIELD DEMONSTRATION DESIGN

As previously discussed, this project entails cometabolic biosparging using a line of biosparging wells installed perpendicular to groundwater flow across the width of a large, dilute cVOC plume containing *cis*-DCE and VC. Contaminated groundwater will be treated as it flows through a biologically active zone created by biosparging oxygen, propane (a primary cometabolic substrate), and ammonia (a gaseous nutrient) to stimulate indigenous bacteria capable of cometabolically degrading *cis*-DCE and VC to below their respective MCLs of 70 µg/L and 2 µg/L. The biosparging system will be designed and constructed to operate completely "off-the-grid", using existing sustainable energy technologies.

The results of sparge testing activities (Section 4.3), and the evaluation of three sparging alternatives (Section 5.0) to create a cometabolic sparging biobarrier, indicate that using multiple vertical biosparging wells will be more effective than horizontal biosparging wells at distributing gaseous amendments within the demonstration area. Site characterization data (Section 4) were used to determine the placement and design of the biosparging well screens, and are currently being used in the final design of the biosparging system.

The preliminary design of the biosparging well layout is provided in **Figures 6.1** and 6**.2**. The design includes a total of 22 vertical biosparging wells (11 deep, 6 intermediate, and 5 shallow) installed across three intervals. The biosparging wells will be installed on 20-ft centers for each interval using direct-push drilling methods. It is anticipated that the gases will be delivered to the aquifer at a rate of approximately 10-15 CFM per biosparging well. Pure, oxygen, propane and ammonia gases will be added in short (5-20 minute) pulses as needed to provide sufficient dissolved oxygen (DO) and substrate to maintain target dissolved gas levels within the treatment zone. The oxygen gas will be added separately from the propane and ammonia to avoid creating a potentially explosive environment within the biosparging system, the tubing runs, and/or the biosparging wells. Compressed nitrogen gas will be sparged before and after each of the pure gas sparging cycles to purge the system, and prevent mixing of the pure oxygen with the flammable gases.

The biosparging system process control and monitoring equipment will be powered by solar energy, and cylinders of the oxygen, propane and ammonia gases will be stored on site in cages. The cylinders will be "ganged" together and equipped with regulators as needed to provide the appropriate delivery pressures and flows. Mass flow controllers/meters will be used to control the gas flow rates, and solenoid valves will be used to direct the gases to individual biosparging wells as needed. If it is determined that oxygen consumption rates are significantly higher than anticipated, the compressed oxygen cylinders may be replaced with liquid oxygen dewars, to minimize the need for frequent cylinder change-outs. The final biosparging system design and operating parameters will be detailed in the Demonstration Work Plan.

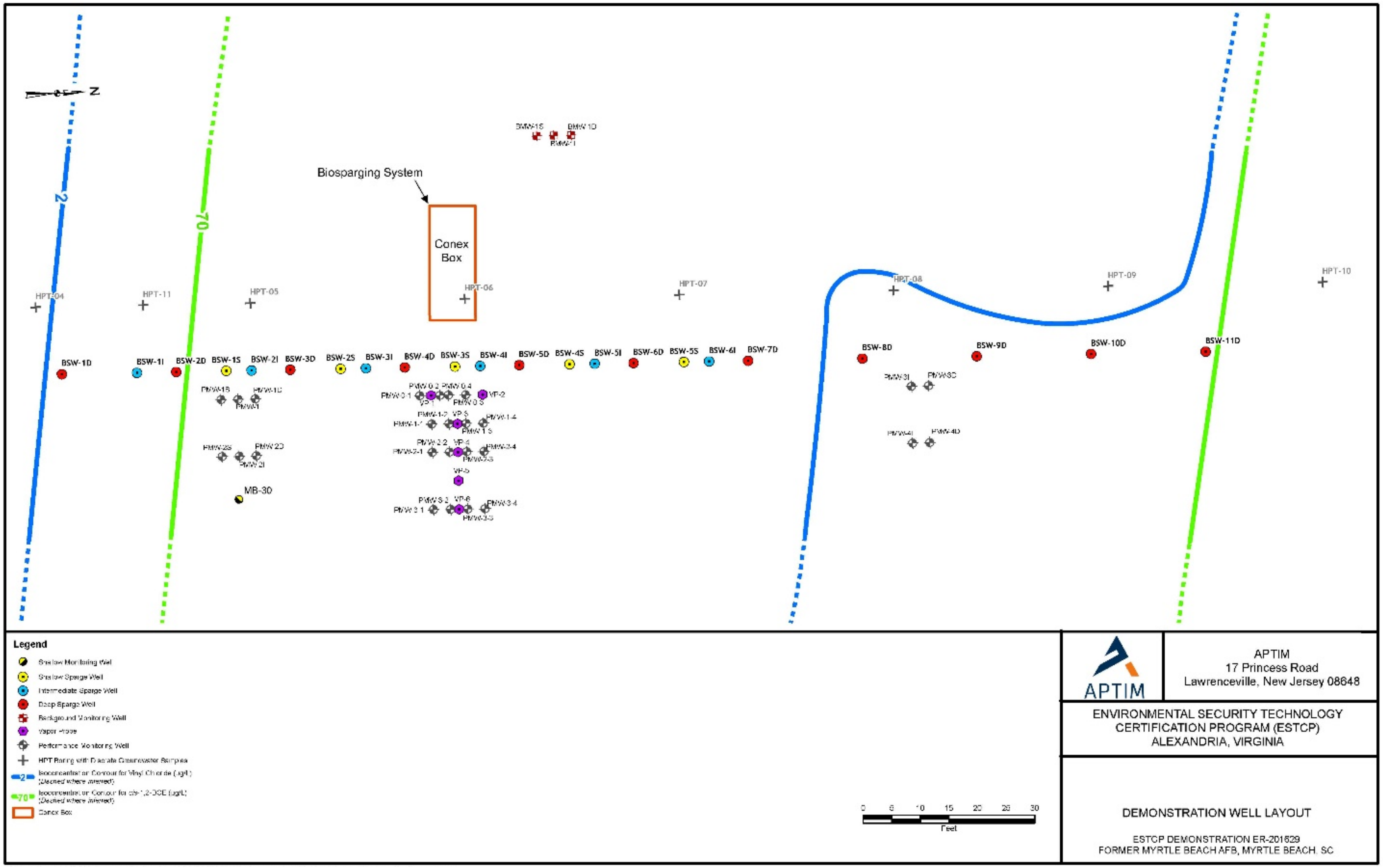


Figure 6.1. Proposed Demonstration Well Layout. The layout includes 22 biosparging wells, 27 performance monitoring wells, 3 background monitoring wells, and 6 vapor probes.

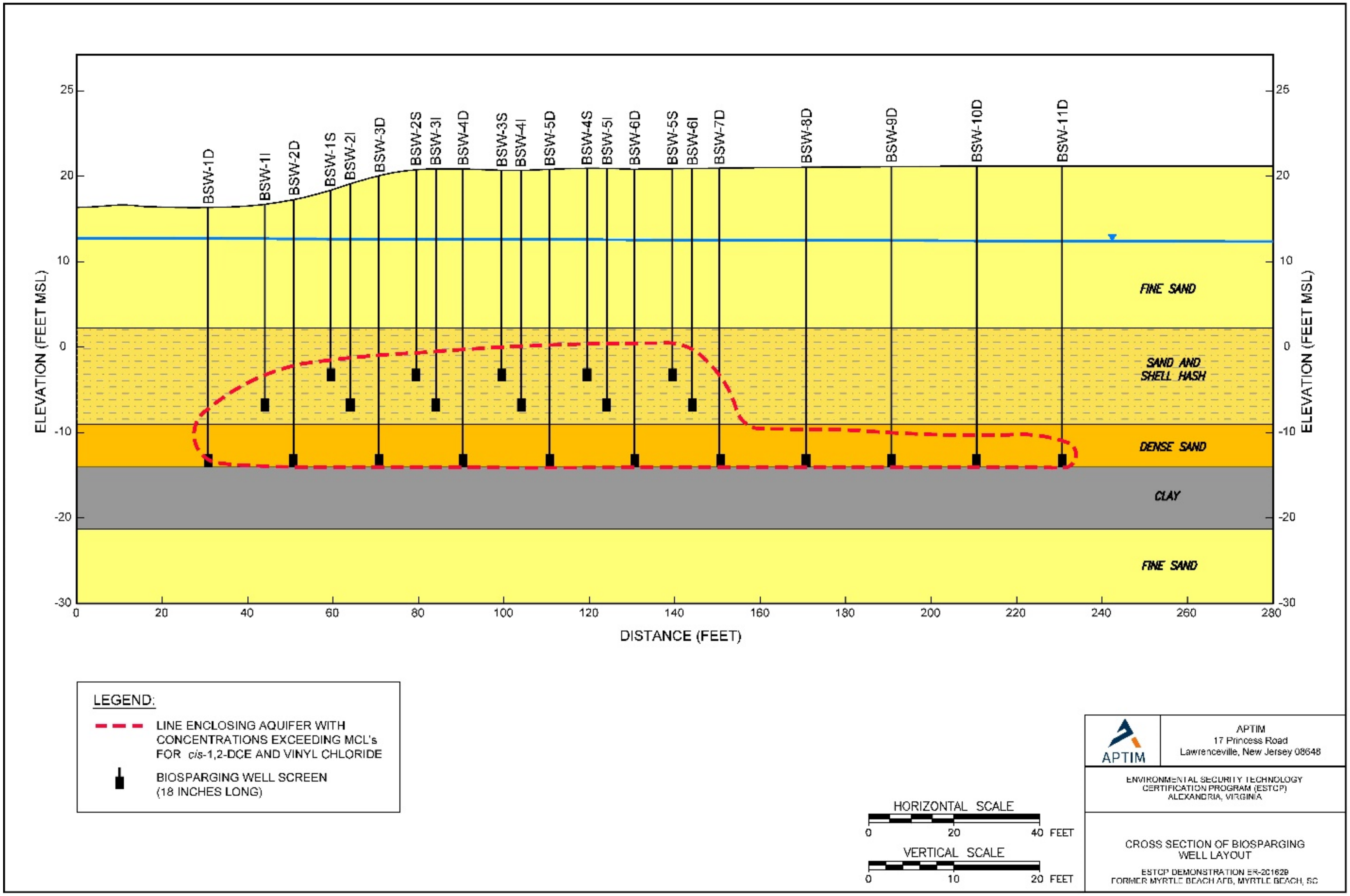


Figure 6.2. Cross Section of Biosparging Well Layout. The layout includes 11 deep, 6 intermediate and 5 shallow biosparging wells to deliver gaseous amendments to the designated treatment zone.

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APPENDIX D ANALYTICAL AND FIELD PARAMETER RESULTS SUMMARY TABLES

Sample ID	PMW-0-1		PMW-0-1		PMW-0-1		PMW-0-1		PMW-0-1		PMW-0-1		PMW-0-1		PMW-0-1		PMW-0-1	
Sampling Date	7/18/2019		8/27/2019		10/23/2019		12/9/2019		2/25/2020		5/11/2020		7/13/2020		9/16/2020		12/22/2020	
Days	-5		35		92		139		217		293		356		421		518	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
dichlorodifluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	0.29	J	0.63	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.19	J
bromomethane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichlorofluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
methylene chloride	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	0.40	J	0.85	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	24.63		31.98		13.77		14.96		3.13		0.86	J	4.35		1.23		13.68	
bromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	0.31	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	0.18	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.79	J	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.69	J	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.90	J	1.00	U	1.00	U
chlorobenzene	0.88	J	1.18		0.53	J	1.00	U	1.00	U	1.00	U	1.11		1.00	U	0.64	J
1,1,1,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.79	J	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	2.06		1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	3.00		1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.76	J	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.88	J	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.89	J	1.00	U	1.00	U
4-isopropyltoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.85	J	1.00	U	1.00	U
1,4-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.90	J	1.00	U	1.00	U
1,2-dichlorobenzene	0.49	J	0.78	J	0.37	J	1.00	U	1.00	U	1.92		1.30		1.00	U	0.42	J
n-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.10		1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	0.71	J	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	0.69	J	1.00	U	1.00	U	1.00	U	1.00	U	3.66		1.00	U	1.00	U
hexachlorobutadiene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	3.57		1.00	U	1.00	U
naphthalene	1.00	U	1.58		1.00	U	1.00	U	1.00	U	1.00	U	13.67		1.00	U	1.00	U
1,2,3-trichlorobenzene	1.00	U	1.17		1.00	U	1.00	U	1.00	U	1.00	U	7.55		1.00	U	1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Acetone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	7.71		5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	4.43		5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	3.45		5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	3.12		5.00	U	5.00	U
2-hexanone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	4.29		5.00	U	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	PMW-0-1	PMW-0-1	PMW-0-1	PMW-0-1	PMW-0-1	PMW-0-1	PMW-0-1	PMW-0-1	PMW-0-1
Sampling Date	7/18/2019	8/27/2019	10/23/2019	12/9/2019	2/25/2020	5/11/2020	7/13/2020	9/16/2020	12/22/2020
Days	-5	35	92	139	217	293	356	421	518
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	0.82								
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	113.13	75.45	11.65	11.40	52.42	6.56	55.01	2.06	48.78
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U
Propane	2.68 U	2.68 U	101.68	861.78	5.71	7.63	103.74	3.81	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.154	0.03	0.02	0.10	0.13	0.07	0.08	0.05	0.20
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	26.50	27.77	30.00	23.52	22.11	18.66	20.55	19.86	23.58
Nitrite as N	0.20 U	0.20 U	0.08 J	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Sulfate as SO4	22.02	150.15 D	83.76	48.25	36.49	32.27	34.28	97.46	19.81
Bromide	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.17 J	0.20 U	0.20 U	0.20 U
Nitrate as N	0.01 J	0.20 U	0.20 U	0.20 U	0.01 J	0.01 J	0.20 U	0.05 J	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS									
pH (SU)	7.03	6.85	6.91	6.98	6.93	7.10	6.62	7.17	7.43
Temperature (°C)	23.11	22.8	23.71	20.40	18.50	22.70	21.00	23.6	20
Dissolved Oxygen (DO; mg/L)	0.33	0.26	0.1	0.08	2.22	0.53	0.07	2.17	0.02
Redox Potential (ORP; mV)	-112.0	-125.6	-24.1	-16.0	42.3	54.7	25	-72	-150.2
Specific Conductivity (mS/cm)	0.527	0.837	0.722	0.561	0.551	0.627	0.520	0.665	0.367
Depth to Water (ft-btoc) prior to purging	7.3	7.6	7.1	7.11	6.50	7.47	6.6	7.63	7.42
Purge Rate (mL/min)	200	270	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)									
Propane Monooxygenase (PPO)									
Ammonia Monooxygenase (AMO)									
Soluble Methane Monooxygenase (SMMO)									
Particulate methane monooxygenase (PMMO)									
Ethene Monooxygenase (EtnC)									
Epoxyalkane transferase (EtnE)									

Notes:
U - The compound was not detected at the indicated PQL concentration.
J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero.
The concentration given is an approximate value.
D - Sample was diluted prior to analysis.
E - Estimated value, beyond linear range.
Blank - Not Analyzed.

Sample ID	PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2		PMW-0-2	
Sampling Date	7/18/2019		8/27/2019		10/2/2019		10/9/2019		10/16/2019		10/23/2019		11/11/2019		11/20/2019		12/9/2019		1/2/2020		1/13/2020		1/14/2020		1/16/2020		1/20/2020		1/28/2020		2/4/2020		2/12/2020		2/25/2020		3/19/2020		4/16/2020		5/11/2020		7/13/2020		9/16/2020		12/22/2020	
Days	-5		35		71		78		85		92		111		120		139		163		174		175		177		181		189		196		204		217		240		268		293		356		421		518	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
dichlorodifluoromethane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	10.05		7.29								6.28		4.20				5.78		1.59								5.84						1.17		2.60				2.01		1.00	U	1.00	U	1.00	U	28.42	
bromomethane	2.00	U	2.00	U							2.00	U	2.00	U			2.00	U	2.00	U							2.00	U					2.00	U	2.00	U			2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichlorofluoromethane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	0.19	J	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
methylene chloride	2.00	U	2.00	U							2.00	U	2.00	U			2.00	U	2.00	U							2.00	U					2.00	U	2.00	U			2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	0.33	J	0.66	J							0.46	J	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	60.87		57.15								70.07		76.33				64.51		60.90								57.77						34.10		40.01				33.41		1.28		1.46		2.25		54.50	
bromochloromethane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	0.78	J	0.90	J							0.86	J	0.92	J			0.78	J	1.00	U							0.65	J					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	0.69	J
1,2-dichloroethane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloropropane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	0.16	J	1.00	U							0.24	J	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chlorobenzene	3.86		2.95								3.10		3.33				2.84		2.30								3.22						1.91		1.98				1.60		1.00	U	1.00	U	1.00	U	2.51	
1,1,1,2-tetrachloroethane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U							2.00	U	2.00	U			2.00	U	2.00	U							2.00	U					2.00	U	2.00	U			2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U							2.00	U	2.00	U			2.00	U	2.00	U							2.00	U					2.00	U	2.00	U			2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-isopropyltoluene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,4-dichlorobenzene	0.14	J	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichlorobenzene	2.08		2.09								1.65		2.22				2.09		1.79								2.68						2.59		2.93				2.47		1.00	U	1.68		1.12		2.24	
n-butylbenzene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U							2.00	U	2.00	U			2.00	U	2.00	U							2.00	U					2.00	U	2.00	U			2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	0.88	J							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
hexachlorobutadiene	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
naphthalene	1.00	U	1.26								1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.93		1.00	U	1.00	U
1,2,3-trichlorobenzene	1.00	U	1.19								1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.02		1.00	U	1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U							1.00	U	1.00	U			1.00	U	1.00	U							1.00	U					1.00	U	1.00	U			1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Acetone	5.00	U	5.00	U							5.00	U	5.00	U			5.00	U	5.00	U							2.99						5.00	U	5.00	U			0.66	J	5.00	U	1.45		5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U							2.00	U	2.00	U			2.00	U	2.00	U							2.00	U					2.00	U	2.00	U			2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	5.00	U							5.00	U	5.00	U			5.00	U	5.00	U							5.00	U					5.00	U	5.00	U			5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U							5.00	U	5.00	U			5.00	U	5.00	U							5.00	U					5.00	U	5.00	U			5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U							5.00	U	5.00	U			5.00	U	5.00	U							5.00	U					5.00	U	5.00	U			5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-hexanone	5.00	U	5.00	U							5.00	U	5.00	U			5.00	U	5.00	U							5.00	U					5.00	U	5.00	U			5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U							5.00	U	5.00	U			5.00	U	5.00	U							5.00	U					5.00	U	5.00	U			5.00	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2	PMW-0-2
Sampling Date	7/18/2019	8/27/2019	10/2/2019	10/9/2019	10/16/2019	10/23/2019	11/11/2019	11/20/2019	12/9/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/11/2020	7/13/2020	9/16/2020	12/22/2020
Days	-5	35	71	78	85	92	111	120	139	163	174	175	177	181	189	196	204	217	240	268	293	356	421	518
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.31																							
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	286.47	49.49	11.27	3.76	7.29	25.69	8.39	5.29	77.85	5.13	1.99	1.96	4.08	70.18	0.67 J	10.92	3.28	136.23	3.63	0.73 J	0.95 U	2.39	3.26	275.87
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	0.88 J	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	0.72 J
Propane	2.68 U	2.68 U	1491.05	655.27	278.62	23.00	4.74	1013.40	242.71	20.23	166.23	272.18	738.20	136.98	0.71 J	76.42	6.57	1.25 J	1.79 J	615.22	8.99	186.25	1.76 J	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.133	0.020 U	0.01 J	0.02 U	0.02 U	0.02 U	0.12	0.04	0.03	0.04	0.13	0.13	0.12	0.14	0.07	0.06	0.03	0.11	0.10	0.05	0.02	0.02	0.14	0.26
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	18.68	22.86		19.85	24.54	20.49	18.63		19.33									21.08			18.92	22.64	26.84	20.68
Nitrite as N	0.20 U	0.20 U		0.20 U	0.07 J	0.08 J	0.20 U		0.20 U									0.20 U			0.20 U	0.20 U	0.20 U	0.05 J
Sulfate as SO4	21.58	270.30 D		249.62 D	267.13 D	124.36 D	152.89 D		80.22									56.94			77.52	73.77	64.57	23.37
Bromide	0.65	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U		0.20 U									0.23			0.32	0.69	0.20 U	0.20 U
Nitrate as N	0.02 J	0.20 U		0.20 U	0.20 U	0.20 U	0.01 J		0.20 U									0.20 U			0.20 U	0.20 U	0.03 J	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U		0.20 U									0.20 U			0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS																								
pH (SU)	6.97	6.81	6.91	6.76	6.74	6.81	6.91	6.83	6.84	6.87	6.8	6.82	6.87	7.08	6.98	6.84	6.82	7.01	6.88	6.92	6.91	6.89	7.17	7.3
Temperature (^{o}C)	23.91	22.9	26.88	21.66	22.64	22.79	19.79	21.17	19.7	18.1	21.1	21.6	21.2	15.2	14.8	17.6	19.4	17.8	21.1	18.7	23.3	21.5	24.2	19.1
Dissolved Oxygen (DO; mg/L)	0.34	6.49	0.2	4.99	7.25	3.20	8.84	5.56	1.67	3.99	5.35	2.44	2.27	1.02	6.2	4.23	4.48	11.1	4.03	3.88	3.38	12.46	2.9	0
Redox Potential (ORP; mV)	-108.3	6	-42.8	66.9	97.9	55.0	83.4	127.9	-16.1	184.1	175	107.7	85.1	15.1	101.9	109.1	92.3	143.9	52.2	83.3	73.7	81.6	9.9	-129.1
Specific Conductivity (mS/cm)	0.626	1.040	0.900	0.981	0.933	0.844	0.903	0.956	0.771	0.896	0.845	0.787	0.772	0.617	0.752	0.704	0.657	0.648	0.63	0.758	0.935	0.783	0.811	0.554
Depth to Water (ft-btoc) prior to purging	7.5	7.9	7.6	7.80	7.67	7.22	7.17	7.15	7.24	6.98	7.14	7.11	7.15	7.34	7.5	7.42	6.67	6.6	7.02	7.34	7.6	10.36	7.73	7.6
Purge Rate (mL/min)	250	240	220	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)																								
Propane Monooxygenase (PPO)																								
Ammonia Monooxygenase (AMO)																								
Soluble Methane Monooxygenase (SMMO)																								
Particulate methane monooxygenase (PMMO)																								
Ethene Monooxygenase (EtnC)																								
Epoxyalkane transferase (EtnE)																								

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3
Sampling Date	7/17/2019	8/29/2019	9/10/2019	10/2/2019	10/9/2019	10/16/2019	10/23/2019	11/11/2019	11/20/2019	12/10/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/12/2020	7/13/2020	9/16/2020	12/22/2020
Days	-6	37	49	71	78	85	92	111	120	140	163	174	175	177	181	189	196	204	217	240	268	294	356	421	518
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
VOCS (GC/MS)	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
dichlorodifluoromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
vinyl chloride	17.14	13.65	20.73				17.47	5.59		12.35	10.86				15.40			3.76	2.48		1.23	6.95	7.59	1.17	55.08
bromomethane	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	1.00 U
chloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	2.39
trichlorofluoromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethylene	0.20 J	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
methylene chloride	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
trans-1,2-dichloroethylene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2,2-dichloropropane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis 1,2- dichloroethylene	69.22	81.11	72.19				71.48	76.42		54.40	65.40				47.32			30.42	29.98		6.51	17.47	20.97	11.96	49.63
bromochloromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloroform	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,1-trichloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
carbon tetrachloride	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloropropene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
benzene	0.77 J	0.86 J	0.93 J				0.84 J	0.86 J		0.77 J	0.93 J				0.70 J			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	0.78 J
1,2-dichloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trichloroethylene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichloropropane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromomethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromodichloromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis-1,3-dichloropropene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
toluene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trans-1,3-dichloropropene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2-trichloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tetrachloroethylene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichloropropane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromochloromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromoethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chlorobenzene	3.86	3.38	3.58				3.41	3.46		3.11	2.96				3.33			1.84	2.03		1.00 U	1.04	1.19	0.58 J	3.15
1,1,1,2-tetrachloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
ethylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
xylenes (m/p)	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
o-xylene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
styrene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromoform	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
isopropyl benzene (cumene)	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromobenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2,2-tetrachloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichloropropane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
n-propyl benzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2-chlorotoluene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-chlorotoluene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3,5-trimethylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tert-butylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,4-trimethylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
sec-butylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichlorobenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-isopropyltoluene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,4-dichlorobenzene	0.22 J	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichlorobenzene	2.61	2.10	2.42				2.19	2.51		2.16	2.22				2.86			2.85	2.95		2.49	2.36	1.81	1.62	2.85
n-butylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromo-3-chloropropane	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
1,2,4-trichlorobenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				0.85 J			1.00 U	0.70 J		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
hexachlorobutadiene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				0.75 J			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
naphthalene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.86			1.00 U	1.53		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichlorobenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.67			1.00 U	1.05		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Methyl tertiary butyl ether	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Acetone	5.00 U	5.00 U	1.25				5.00 U	0.79 J		1.49 J	5.00 U				0.83 J			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
carbon disulfide	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
2-butanone (MEK)	5.00 U	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
tetrahydrofuran (THF)	5.00 U	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
4-methyl-2-pentanone (MIBK)	5.00 U	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-hexanone	5.00 U	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-chloroethyl vinyl ether	5.00 U	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U

Sample ID	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3
Sampling Date	7/17/2019	8/29/2019	9/10/2019	10/2/2019	10/9/2019	10/16/2019	10/23/2019	11/11/2019	11/20/2019	12/10/2019	1/2/2020	1/13/2020	1/14/2020
Days	-6	37	49	71	78	85	92	111	120	140	163	174	175
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.47												
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	406.92	81.33		12.16	6.12	18.34	59.92	12.21	76.51	51.80	29.55	10.81	3.61
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	1.20 J	2.22 U	0.75 J	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U
Propane	2.68 U	2.68 U	2.68 U	707.17	746.08	379.75	22.24	2.64 J	567.10	615.13	8.09	55.31	162.04
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.147	0.02		0.01 J	0.01 J	0.02 U	0.01 J	0.06	0.14	0.03	0.02 U	0.13	0.15
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	15.81	14.78	13.58		14.46	16.06	15.21	14.04		14.57			
Nitrite as N	0.20 U	0.20 U	0.20 U		0.20 U	0.07 J	0.09 J	0.20 U		0.20 U			
Sulfate as SO4	18.50	116.46 D	89.42		185.18 D	149.57 D	53.09	93.68		75.52			
Bromide	0.78	0.20 U	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U		0.20 U			
Nitrate as N	0.04 J	0.20 U	0.20 U		0.20 U	0.20 U	0.03 J	0.01 J		0.20 U			
Phosphate as P, ortho	0.12 J	0.20 U	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U		0.20 U			
FIELD PARAMETERS													
pH (SU)	6.97	7.05	6.86	6.87	6.73	6.80	6.94	6.94	6.94	6.91	6.86	6.86	6.87
Temperature (°C)	24.80	22.84	22.00	29.95	24.10	23.09	21.57	21.1	20.83	19.2	18.1	21.5	21.7
Dissolved Oxygen (DO; mg/L)	0.61	0.88	1.5	0.86	3.15	4.18	0.74	7.66	5.93	0.51	3.87	2.41	2.37
Redox Potential (ORP; mV)	-99.5	7.7	-47.0	-32.8	56.3	131.8	59.8	83.7	160.1	66.4	139.9	93.4	100.9
Specific Conductivity (mS/cm)	0.637	0.726	0.808	0.761	0.874	0.755	0.722	0.808	0.736	0.762	0.778	0.784	0.786
Depth to Water (ft-btoc) prior to purging	7.7	7.9	6.43	7.84	8.02	7.91	7.49	7.44	7.32	7.54	7.21	7.3	7.36
Purge Rate (mL/min)	200	240	250	200	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)	4.90E+00 U		4.90E+00 U										
Propane Monooxygenase (PPO)	3.21E+01		1.85E+01										
Ammonia Monooxygenase (AMO)	4.90E+00 U		4.90E+00 U										
Soluble Methane Monooxygenase (SMMO)	4.90E+00 U		6.92E+02										
Particulate methane monooxygenase (PMMO)	4.90E+00 U		4.90E+00 U										
Ethene Monooxygenase (EtnC)	4.90E+00 U		4.90E+00 U										
Epoxyalkane transferase (EtnE)	8.00E+00		1.86E+02										

Sample ID	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3	PMW-0-3
Sampling Date	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/12/2020	7/13/2020	9/16/2020	12/22/2020
Days	177	181	189	196	204	217	240	268	294	356	421	518
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane												
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	15.48	156.04	3.42	3.59	1.93	43.09	15.51	3.81	45.85	193.59	1.10	330.72
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	2.22 U	0.74 J	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	0.86 J
Propane	139.95	14.91	28.70	183.73	46.29	16.07	2.68 U	85.55	8.03	15.67	37.11	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.15	0.21	0.09	0.05	0.04	0.15	0.20	0.06	0.06	0.07	0.11	0.32
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride						16.76			16.40	16.28	16.37	15.45
Nitrite as N						0.20 U			0.20 U	0.20 U	0.20 U	0.20 U
Sulfate as SO4						54.63			40.64	38.65	56.78	19.27
Bromide						0.27			0.34	0.50	0.53	0.34
Nitrate as N						0.20 U			0.01 J	0.20 U	0.04 J	0.20 U
Phosphate as P, ortho						0.20 U			0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS												
pH (SU)	6.94	7.07	7.00	6.91	6.91	6.94	7.02	6.97	7.01	7.02	7.15	7.43
Temperature (°C)	21	13.6	15.5	17.8	19.5	17.7	21.5	19.2	17.2	22.2	22.8	19.4
Dissolved Oxygen (DO; mg/L)	0.43	0.79	9.55	3.56	8.6	6.4	0.22	1.37	1.22	4.03	5.94	0
Redox Potential (ORP; mV)	37.3	70.4	107.7	118.1	99.7	99.6	32.9	103.8	131.5	51.3	51.7	-129.2
Specific Conductivity (mS/cm)	0.732	0.587	0.674	0.705	0.682	0.637	0.574	0.719	0.834	0.692	0.773	0.547
Depth to Water (ft-btoc) prior to purging	7.37	7.54	7.72	7.65	6.91	6.84	7.27	7.57	7.89	6.96	7.98	7.58
Purge Rate (mL/min)	200	200	200	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)									5.15E+03		8.51E+02	4.64E+02
Propane Monooxygenase (PPO)									2.79E+04		2.96E+04	2.29E+04
Ammonia Monooxygenase (AMO)									4.80E+00 U		5.00E-01 J	9.30E-02 J
Soluble Methane Monooxygenase (SMMO)									5.35E+01		8.00E+00	1.60E+00 J
Particulate methane monooxygenase (PMMO)									4.80E+00 U		4.50E+00 U	4.60E+00 U
Ethene Monooxygenase (EtnC)									4.80E+00 U		1.85E+01	5.00E+00
Epoxyalkane transferase (EtnE)									1.55E+03		1.13E+02	4.88E+02

Notes:

U - The compound was not detected at the indicated PQL concentration.
J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.
D - Sample was diluted prior to analysis.
E - Estimated value, beyond linear range.
Blank - Not Analyzed.

Sample ID	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4
Sampling Date	7/17/2019	8/29/2019	9/10/2019	10/2/2019	10/9/2019	10/16/2019	10/23/2019	11/11/2019	11/20/2019	12/10/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/12/2020	7/13/2020	9/16/2020	12/22/2020
Days	-6	37	49	71	78	85	92	111	120	140	163	174	175	177	181	189	196	204	217	240	268	294	356	421	518
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
VOCS (GC/MS)	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
dichlorodifluoromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
vinyl chloride	3.75	1.99	1.92				1.00	1.00 U		1.74	0.82 J				1.47			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	22.41
bromomethane	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
chloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	0.92 J
trichlorofluoromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethylene	0.25 J	1.00 U	1.00 U				0.28 J	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
methylene chloride	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
trans-1,2-dichloroethylene	1.84	2.74	1.87				0.83 J	1.00 U		0.96 J	0.76 J				0.89 J			0.67 J	0.90 J		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2,2-dichloropropane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis 1,2- dichloroethylene	92.64	94.99	92.81				86.98	69.78		84.83	127.92				81.80			51.32	72.62		8.46	10.83	13.18	5.25	84.40
bromochloromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloroform	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,1-trichloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
carbon tetrachloride	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloropropene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
benzene	0.55 J	0.69 J	0.59 J				0.52 J	1.00 U		1.00 U	0.87 J				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	0.63 J
1,2-dichloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trichloroethylene	1.00 U	0.52 J	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichloropropane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromomethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromodichloromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis-1,3-dichloropropene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
toluene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trans-1,3-dichloropropene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2-trichloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tetrachloroethylene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichloropropane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromochloromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromoethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chlorobenzene	1.94	2.02	2.01				1.66	1.33		1.61	2.32				2.26			0.92 J	1.01		1.00 U	1.00 U	1.00 U	1.00 U	2.78
1,1,1,2-tetrachloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
ethylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
xylenes (m/p)	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
o-xylene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
styrene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromoform	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
isopropyl benzene (cumene)	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromobenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2,2-tetrachloroethane	1.00 U	1.00 U	0.67 J				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichloropropane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
n-propyl benzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2-chlorotoluene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-chlorotoluene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3,5-trimethylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tert-butylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,4-trimethylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
sec-butylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichlorobenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-isopropyltoluene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,4-dichlorobenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichlorobenzene	1.18	1.05	1.25				1.13	1.03		0.91 J	1.39				1.80			1.27	1.70		0.82 J	0.89 J	1.00 U	1.00 U	1.88
n-butylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromo-3-chloropropane	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
1,2,4-trichlorobenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
hexachlorobutadiene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
naphthalene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichlorobenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Methyl tertiary butyl ether	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Acetone	0.17 J	5.00 U	1.69				5.00 U	5.00 U		1.87 J	5.00 U				1.05			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
carbon disulfide	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
2-butanone (MEK)	5.00 U	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
tetrahydrofuran (THF)	5.00 U	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
4-methyl-2-pentanone (MIBK)	5.00 U	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-hexanone	5.00 U	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-chloroethyl vinyl ether	5.00 U	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U

Sample ID	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4	PMW-0-4
Sampling Date	7/17/2019	8/29/2019	9/10/2019	10/2/2019	10/9/2019	10/16/2019	10/23/2019	11/11/2019	11/20/2019	12/10/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/12/2020	7/13/2020	9/16/2020	12/22/2020
Days	-6	37	49	71	78	85	92	111	120	140	163	174	175	177	181	189	196	204	217	240	268	294	356	421	518
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	2.01	1.45	1.60				1.28			1.62									2.39				4.11	1.00 U	2.96
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	165.92	76.04		16.15	2.08	1.99	2.58	1.63	39.52	68.93	2.07	1.28	1.45	4.03	50.50	0.91 J	0.98	1.03	2.96	18.90	1.11	19.97	3.58	0.41 J	314.20
Ethane	0.66 J	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	0.79 J	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U
Propane	1.51 J	2.68 U	2.68 U	700.16	481.43	409.05	82.35	2.69	2155.85	284.91	4.54	259.60	320.37	106.24	93.64	37.47	92.78	6.41	43.51	2.68 U	24.89	38.94	13.24	2.68 U	2.68 U
Acetylene	1.83 J	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.175	0.02 U		0.01 J	0.03	0.03	0.10	0.13	0.15	0.13	0.13	0.18	0.19	0.08	0.15	0.12	0.12	0.06	0.13	0.20	0.07	0.09	0.07	0.13	0.23
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	13.02	13.82	12.71		13.95	16.23	16.09	17.90		16.06									14.74			14.56	14.23	14.92	18.55
Nitrite as N	0.20 U	0.20 U	0.20 U		0.20 U	0.08 J	0.08 J	0.20 U		0.20 U									0.20 U			0.20 U	0.20 U	0.20 U	0.20 U
Sulfate as SO4	16.32	193.47 D	51.66		128.16 D	159.98 D	91.37	75.77		44.70									41.43			37.90	38.70	43.43	19.33
Bromide	0.60	0.20 U	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U		0.20 U									0.23			0.32	0.43	0.46	0.29
Nitrate as N	0.20 U	0.20 U	0.20 U		0.20 U	0.02 J	0.02 J	0.20 U		0.20 U									0.20 U			0.01 J	0.01 J	0.05 J	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U		0.20 U									0.20 U			0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS																									
pH (SU)	7.01	6.96	6.89	6.85	6.78	6.76	6.95	6.95	6.95	6.87	6.9	6.85	6.95	6.95	6.94	7.02	6.95	6.96	6.99	7.00	7.00	7.07	7	7.1	7.3
Temperature (°C)	25.11	22.39	22.50	26.60	23.80	23.24	17.27	20.74	20.32	19.2	18.2	20.1	20.2	19.1	13.4	16.3	19.5	20.4	18.6	22.1	20.1	17.6	22.8	24.1	19
Dissolved Oxygen (DO; mg/L)	0.50	7.15	14.3	2.29	20.09	21.06	4.5	31.32	13.91	8.77	25.30	17.29	14.42	13.09	7.6	27.98	29.81	23.19	28.16	1.28	10.55	7.97	14.02	20.24	0.02
Redox Potential (ORP; mV)	-110.0	56.8	54.6	65.1	181.0	197.9	173.2	161.3	168.8	156.8	161.2	164	217.1	123.6	167.2	150.6	179.4	168.9	130.4	98.7	154.8	141.5	139.7	85.4	-124.2
Specific Conductivity (mS/cm)	0.528	0.849	0.709	0.717	0.743	0.755	0.790	0.754	0.693	0.686	0.703	0.734	0.746	0.746	0.625	0.631	0.677	0.636	0.637	0.573	0.681	0.824	0.681	0.729	0.527
Depth to Water (ft-btoc) prior to purging	7.9	8.1	6.6	8.01	8.20	8.11	7.64	7.61	7.22	7.73	7.41	7.42	7.54	7.61	7.76	7.91	7.86	7.13	7.04	7.44	7.77	8.07	7.16	8.17	7.74
Purge Rate (mL/min)	200	200	250	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)	4.90E+00 U		4.90E+00 U																			8.21E+04		1.00E+04	
Propane Monooxygenase (PPO)	3.80E+00 J		1.24E+01																			1.42E+04		1.00E+04	
Ammonia Monooxygenase (AMO)	4.90E+00 U		4.90E+00 U																			1.60E+00 J		1.50E+00 J	
Soluble Methane Monooxygenase (SMMO)	4.90E+00 U		2.59E+03																			1.41E+02		3.47E+01	
Particulate methane monooxygenase (PMMO)	4.90E+00 U		3.80E+00 J																			4.60E+00 U		4.60E+00 U	
Ethene Monooxygenase (EtnC)	4.90E+00 U		2.20E+01																			2.20E+01		4.60E+00 U	
Epoxyalkane transferase (EtnE)	4.90E+00 U		4.90E+00 U																			1.81E+03		2.69E+01	

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1
Sampling Date	7/18/2019	8/27/2019	10/23/2019	12/9/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	5/11/2020	7/13/2020	9/16/2020	12/21/2020
Days	-5	35	92	139	163	174	175	177	181	189	196	204	217	240	293	356	421	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
VOCS (GC/MS)	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
dichlorodifluoromethane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
chloromethane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
vinyl chloride	1.00 U	1.34	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	0.49 J
bromomethane	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U
chloroethane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
trichlorofluoromethane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethylene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
methylene chloride	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U
trans-1,2-dichloroethylene	0.68 J	0.76 J	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
2,2-dichloropropane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
cis 1,2- dichloroethylene	32.71	31.73	17.76	27.09	7.81				10.26			4.44	2.78		1.00 U	1.72	1.00 U	23.91
bromochloromethane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
chloroform	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
1,1,1-trichloroethane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
carbon tetrachloride	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloropropene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
benzene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	0.29 J
1,2-dichloroethane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
trichloroethylene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	0.36 J
1,2-dichloropropane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
dibromomethane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
bromodichloromethane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
cis-1,3-dichloropropene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
toluene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
trans-1,3-dichloropropene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
1,1,2-trichloroethane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
tetrachloroethylene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichloropropane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
dibromochloromethane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromoethane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
chlorobenzene	1.29	1.03	0.54 J	0.70 J	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	0.82 J
1,1,1,2-tetrachloroethane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
ethylbenzene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
xylenes (m/p)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U
o-xylene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
styrene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
bromoform	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U
isopropyl benzene (cumene)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
bromobenzene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
1,1,2,2-tetrachloroethane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichloropropane	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
n-propyl benzene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
2-chlorotoluene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
4-chlorotoluene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
1,3,5-trimethylbenzene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
tert-butylbenzene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
1,2,4-trimethylbenzene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
sec-butylbenzene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichlorobenzene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
4-isopropyltoluene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
1,4-dichlorobenzene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichlorobenzene	1.00 U	0.59 J	0.42 J	1.00 U	1.00 U				0.73 J			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	0.60 J
n-butylbenzene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromo-3-chloropropane	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U
1,2,4-trichlorobenzene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
hexachlorobutadiene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
naphthalene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichlorobenzene	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
Methyl tertiary butyl ether	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U
Acetone	5.00 U	5.00 U	5.00 U	1.64 J	5.00 U				2.33			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U
carbon disulfide	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U
2-butanone (MEK)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U
tetrahydrofuran (THF)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U
4-methyl-2-pentanone (MIBK)	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U
2-hexanone	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U
2-chloroethyl vinyl ether	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U

Sample ID	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1	PMW-1-1
Sampling Date	7/18/2019	8/27/2019	10/23/2019	12/9/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	5/11/2020	7/13/2020	9/16/2020	12/21/2020
Days	-5	35	92	139	163	174	175	177	181	189	196	204	217	240	293	356	421	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.00																	
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	138.96	40.82	2.17	11.19	3.08	3.04	1.27	1.48	7.43	0.80 J	1.96	1.33	12.19	1.62	0.95 U	7.38	0.62 J	89.30
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U
Propane	2.68 U	2.68 U	152.25	1467.34	4.54	7.21	25.80	30.36	84.57	1.76 J	35.03	9.89	2.68 U	2.71	59.23	551.21	2.68 U	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.175	0.03	0.02 U	0.01 J	0.01 J	0.11	0.13	0.09	0.12	0.06	0.05	0.04	0.06	0.09	0.02	0.02	0.04	0.24
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	28.37	22.52	30.46	28.19									27.49		24.43	25.85	22.11	27.99
Nitrite as N	0.20 U	0.20 U	0.12 J	0.20 U									0.20 U		0.20 U	0.20 U	0.20 U	0.20 U
Sulfate as SO4	22.99	336.57 D	214.76 D	115.69 D									84.40		76.00	84.46	93.40	26.94
Bromide	0.20 U	0.20 U	0.20 U	0.20 U									0.16 J		0.20 U	0.20 U	0.20 U	0.20 U
Nitrate as N	0.03 J	0.20 U	0.04 J	0.20 U									0.04 J		0.20 U	0.20 U	0.05 J	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U	0.20 U									0.20 U		0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS																		
pH (SU)	7.02	6.71	6.74	6.93	6.93	6.91	6.87	6.89	6.99	6.93	6.97	6.9	6.95	6.98	6.98	7.03	7.07	7.11
Temperature (°C)	23.17	24	23.97	19.90	18.50	19.60	20.90	23	15.1	18.3	19.2	18.7	18.6	22.1	23.6	22.5	26.2	19.8
Dissolved Oxygen (DO; mg/L)	0.45	0.52	4.5	0.05	3.66	6.94	7.7	5.42	4.16	11.76	9.31	6.64	12.25	3.55	8.89	18.56	22.13	0.13
Redox Potential (ORP; mV)	-94.7	-48.4	91.8	-37.7	142.6	144.7	154.7	141.6	105.3	135.1	150.2	144	157.3	108.1	140	166.8	68.7	-8.8
Specific Conductivity (mS/cm)	0.567	1.286	0.983	0.709	0.706	0.748	0.786	0.800	0.740	0.864	0.724	0.7	0.582	0.558	0.873	0.749	0.794	0.516
Depth to Water (ft-btoc) prior to purging	7.3	7.79	7.12	7.30	6.87	7.01	7.01	7.03	7.22	7.37	7.3	6.54	6.52	6.95	7.5	6.62	7.6	7.42
Purge Rate (mL/min)	250	250	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)																		
Propane Monooxygenase (PPO)																		
Ammonia Monooxygenase (AMO)																		
Soluble Methane Monooxygenase (SMMO)																		
Particulate methane monooxygenase (PMMO)																		
Ethene Monooxygenase (EtnC)																		
Epoxyalkane transferase (EtnE)																		

Notes:
U - The compound was not detected at the indicated PQL concentration.
J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.
D - Sample was diluted prior to analysis.
E - Estimated value, beyond linear range.
Blank - Not Analyzed.

Sample ID	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2
Sampling Date	7/18/2019	8/27/2019	10/2/2019	10/9/2019	10/16/2019	10/24/2019	11/11/2019	11/20/2019	12/9/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/11/2020	7/13/2020	9/16/2020	12/22/2020
Days	-5	35	71	78	85	93	111	120	139	163	174	175	177	181	189	196	204	217	240	268	293	356	421	518
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
VOCS (GC/MS)	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
dichlorodifluoromethane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloromethane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
vinyl chloride	9.92	8.00				8.29	2.36		11.61	4.68				3.91			1.00 U	0.88 J		1.00 U	1.00 U	1.00 U	1.00 U	40.29
bromomethane	2.00 U	2.00 U				0.16 J	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
chloroethane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.08
trichlorofluoromethane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethylene	0.14 J	1.00 U				0.05 J	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
methylene chloride	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
trans-1,2-dichloroethylene	1.00 U	1.00 U				0.17 J	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethane	1.00 U	1.00 U				0.10 J	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2,2-dichloropropane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis 1,2- dichloroethylene	59.34	62.45				69.40	51.25		57.25	67.01				49.80			6.98	32.07		8.68	1.00 U	1.00 U	1.00 U	52.28
bromochloromethane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloroform	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,1-trichloroethane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
carbon tetrachloride	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloropropene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
benzene	0.80 J	0.66 J				0.86 J	1.00 U		0.81 J	0.85 J				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	0.90 J
1,2-dichloroethane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trichloroethylene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichloropropane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromomethane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromodichloromethane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis-1,3-dichloropropene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
toluene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trans-1,3-dichloropropene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2-trichloroethane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tetrachloroethylene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichloropropane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromochloromethane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromoethane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chlorobenzene	3.77	2.49				1.00 U	2.64		2.84	2.58				2.90			1.00 U	1.40		1.00 U	1.00 U	1.00 U	1.00 U	3.11
1,1,1,2-tetrachloroethane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
ethylbenzene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
xylenes (m/p)	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
o-xylene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
styrene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromoform	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
isopropyl benzene (cumene)	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromobenzene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2,2-tetrachloroethane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichloropropane	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
n-propyl benzene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2-chlorotoluene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-chlorotoluene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3,5-trimethylbenzene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tert-butylbenzene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,4-trimethylbenzene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
sec-butylbenzene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichlorobenzene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-isopropyltoluene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,4-dichlorobenzene	0.19 J	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichlorobenzene	2.40	1.81				1.00 U	1.89		2.18	2.17				2.83			2.20	2.63		1.81	1.00 U	1.00 U	1.00 U	2.55
n-butylbenzene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromo-3-chloropropane	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
1,2,4-trichlorobenzene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
hexachlorobutadiene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
naphthalene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichlorobenzene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Methyl tertiary butyl ether	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Acetone	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				2.11			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
carbon disulfide	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
2-butanone (MEK)	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
tetrahydrofuran (THF)	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
4-methyl-2-pentanone (MIBK)	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-hexanone	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-chloroethyl vinyl ether	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U

Sample ID	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2
Sampling Date	7/18/2019	8/27/2019	10/2/2019	10/9/2019	10/16/2019	10/24/2019	11/11/2019	11/20/2019	12/9/2019	1/2/2020	1/13/2020	1/14/2020
Days	-5	35	71	78	85	93	111	120	139	163	174	175
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.10											
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	283.96	5.12	9.44	4.00	5.95	10.02	1.81	4.00	158.15	31.81	2.40	2.01
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	0.81 J	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U
Propane	2.68 U	2.68 U	1185.53	1447.63	282.90	23.75	2.13 J	12.26	313.33	1.11 J	2.48 J	5.90
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.161	0.020 U	0.02 U	18.50 D	1.90	0.02	0.13	0.07	0.22	0.02 U	0.15	0.14
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	19.46	18.65		15.56	19.24	15.56	15.85		16.12			
Nitrite as N	0.20 U	0.20 U		0.20 U	0.10 J	0.20 U	0.20 U		0.20 U			
Sulfate as SO4	21.49	248.20 D		283.26 D	327.57 D	179.97 D	210.19 D		54.78			
Bromide	0.69	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U		0.20 U			
Nitrate as N	0.03 J	0.20 U		0.20 U	0.20 U	0.20	0.20 U		0.20 U			
Phosphate as P, ortho	0.20 U	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U		0.20 U			
FIELD PARAMETERS												
pH (SU)	6.97	6.83	6.76	6.90	6.85	6.86	6.83	6.85	6.93	6.93	6.83	6.87
Temperature (^oC)	23.09	22.6	25.51	22.77	23.50	19.44	21.02	21.27	19.9	18.2	20.4	22
Dissolved Oxygen (DO; mg/L)	0.38	0.18	0.1	0.10	0.12	0.17	0.63	0.30	0.05	0.16	2.87	2.47
Redox Potential (ORP; mV)	-104.0	-77.8	-62.3	-50.4	-23.8	9.1	-43.4	-69.4	-37.7	-19.9	59.8	80.5
Specific Conductivity (mS/cm)	0.631	1.133	1.036	1.041	1.025	0.957	0.994	0.926	0.709	-0.817	0.812	0.795
Depth to Water (ft-btoc) prior to purging	7.5	7.99	7.63	7.81	7.74	7.37	7.23	7.2	7.3	7.02	7.14	7.14
Purge Rate (mL/min)	260	230	220	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)												
Propane Monooxygenase (PPO)												
Ammonia Monooxygenase (AMO)												
Soluble Methane Monooxygenase (SMMO)												
Particulate methane monooxygenase (PMMO)												
Ethene Monooxygenase (EtnC)												
Epoxyalkane transferase (EtnE)												

Sample ID	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2	PMW-1-2
Sampling Date	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/11/2020	7/13/2020	9/16/2020	12/22/2020
Days	177	181	189	196	204	217	240	268	293	356	421	518
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane												
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	1.74	8.24	0.92 J	0.95 U	0.37 J	8.86	0.51 J	0.95 U	0.95 U	1.69	0.78 J	304.60
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	0.75 J
Propane	694.36	417.36	1.53 J	423.74	0.61 J	4.76	2.68 U	58.52	2.68 U	3.74	2.68 U	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.14	9.20 D	0.43	6.60 D	2.20 D	0.28	0.30	1.38 D	0.21	0.60 D	5.80 D	0.80 D
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride						18.48			16.24	20.14	21.20	16.56
Nitrite as N						0.20 U			0.20 U	0.20 U	0.49	0.20 U
Sulfate as SO4						58.92			55.23	107.90 D	39.47	21.80
Bromide						0.24			0.30	0.43	0.39	0.20 U
Nitrate as N						0.02 J			0.20 U	0.06 J	0.23	0.01 J
Phosphate as P, ortho						0.20 U			0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS												
pH (SU)	6.9	7.03	7.00	6.9	7.04	7.04	6.93	6.96	6.99	7.14	7.04	7.38
Temperature (^oC)	22	15.1	17.2	19.5	18.8	18.8	21.3	20.5	24.3	21.8	25.1	18.9
Dissolved Oxygen (DO; mg/L)	2.27	0.12	2.69	1.97	5.11	16.77	12.8	4.6	21.32	29.77	3.46	0
Redox Potential (ORP; mV)	91.6	-24	55.5	85.6	91.9	18.8	150	142.5	167.9	173.2	21.4	85.1
Specific Conductivity (mS/cm)	0.758	0.636	0.732	0.69	0.661	0.556	0.634	0.705	0.872	0.696	0.767	0.544
Depth to Water (ft-btoc) prior to purging	7.14	7.34	7.53	7.45	6.74	6.67	7.04	7.4	7.64	6.8	7.77	7.6
Purge Rate (mL/min)	200	200	200	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)												
Propane Monooxygenase (PPO)												
Ammonia Monooxygenase (AMO)												
Soluble Methane Monooxygenase (SMMO)												
Particulate methane monooxygenase (PMMO)												
Ethene Monooxygenase (EtnC)												
Epoxyalkane transferase (EtnE)												

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3
Sampling Date	7/17/2019	8/29/2019	9/10/2019	10/2/2019	10/9/2019	10/16/2019	10/23/2019	11/11/2019	11/20/2019	12/9/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/12/2020	7/13/2020	9/16/2020	12/22/2020
Days	-6	37	49	71	78	85	92	111	120	139	163	174	175	177	181	189	196	204	217	240	268	294	356	421	518
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
VOCS (GC/MS)	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
dichlorodifluoromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
vinyl chloride	14.37	7.16	13.73				4.09	2.53		14.85	1.70				1.98			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	54.43
bromomethane	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
chloroethane	0.29 J	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	2.79
trichlorofluoromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethylene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
methylene chloride	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
trans-1,2-dichloroethylene	0.05 J	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2,2-dichloropropane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis 1,2- dichloroethylene	67.34	75.15	64.91				59.44	64.70		91.97	44.75				32.01			7.76	4.96		0.85 J	1.00 U	1.00 U	1.00 U	59.39
bromochloromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloroform	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,1-trichloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
carbon tetrachloride	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloropropene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
benzene	0.57 J	0.64 J	0.89 J				0.58 J	1.00 U		1.12	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	0.94 J
1,2-dichloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trichloroethylene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichloropropane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromomethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromodichloromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis-1,3-dichloropropene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
toluene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trans-1,3-dichloropropene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2-trichloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tetrachloroethylene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichloropropane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromochloromethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromoethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chlorobenzene	3.77	3.25	3.65				2.86	2.99		4.70	1.93				2.25			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	3.52
1,1,1,2-tetrachloroethane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
ethylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
xylenes (m/p)	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
o-xylene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
styrene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromoform	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
isopropyl benzene (cumene)	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromobenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2,2-tetrachloroethane	1.00 U	1.00 U	0.54 J				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichloropropane	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
n-propyl benzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2-chlorotoluene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-chlorotoluene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3,5-trimethylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tert-butylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,4-trimethylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
sec-butylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichlorobenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-isopropyltoluene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,4-dichlorobenzene	0.19 J	1.00 U	0.51 J				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichlorobenzene	2.27	2.15	2.57				2.10	2.00		3.51	2.25				3.01			2.35	2.41		2.33	1.41	0.66 J	0.84 J	2.95
n-butylbenzene	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromo-3-chloropropane	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
1,2,4-trichlorobenzene	1.00 U	1.00 U	0.69 J				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		0.66 J	1.00 U	1.00 U	1.00 U	1.00 U
hexachlorobutadiene	1.00 U	1.00 U	0.63 J				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		0.85 J	1.00 U	1.00 U	1.00 U	1.00 U
naphthalene	1.00 U	1.00 U	1.03				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.45	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichlorobenzene	1.00 U	1.00 U	1.00				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.03	1.00 U	1.00 U	1.00 U	1.00 U
Methyl tertiary butyl ether	1.00 U	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Acetone	5.00 U	5.00 U	0.81 J				5.00 U	5.00 U		4.89 J	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	2.79	5.00 U	5.00 U
carbon disulfide	2.00 U	2.00 U	2.00 U				2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
2-butanone (MEK)	5.00 U	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
tetrahydrofuran (THF)	5.00 U	5.00 U	0.50 J				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
4-methyl-2-pentanone (MIBK)	5.00 U	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-hexanone	5.00 U	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-chloroethyl vinyl ether	5.00 U	5.00 U	5.00 U				5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U

Sample ID	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3	PMW-1-3
Sampling Date	7/17/2019	8/29/2019	9/10/2019	10/2/2019	10/9/2019	10/16/2019	10/23/2019	11/11/2019	11/20/2019	12/9/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/12/2020	7/13/2020	9/16/2020	12/22/2020
Days	-6	37	49	71	78	85	92	111	120	139	163	174	175	177	181	189	196	204	217	240	268	294	356	421	518
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.60	1.18	1.44				1.00 U			1.15									2.43				1.13	0.90 J	1.42
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	352.61	24.71		3.88	3.90	3.73	1.80	2.10	3.69	17.20	7.54	1.32	1.62	2.32	7.74	1.45	1.39	0.52 J	5.09	1.91	0.45 J	0.95 U	2.67	0.46 J	365.24
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	0.75 J	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U
Propane	2.68 U	2.68 U	2.68 U	588.61	724.58	1551.91	274.40	13.80	208.53	3905.05	17.02	6.40	166.56	70.84	53.26	80.77	67.59	5.33	8.95	7.52	76.01	2.68 U	50.04	1.87 J	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.21	0.02 U		0.02 U	0.37	1.30	0.42	0.35	0.20	0.26	0.08	0.12	0.16	0.09	0.13	0.09	0.06	0.15	0.10	0.14	0.03	0.03	0.75 D	0.10	0.37
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	16.21	15.16	12.72		13.72	16.16	15.42	14.69		13.94									15.88			16.20	16.15	16.15	14.94
Nitrite as N	0.20 U	0.20 U	0.20 U		0.20 U	0.11 J	0.10 J	0.08 J		0.20 U									0.20 U			0.20 U	0.20 U	0.20 U	0.20 U
Sulfate as SO4	29.22	413.98 D	223.30 D		247.74 D	251.08 D	206.35 D	199.32 D		143.00 D									94.75			88.78	90.19	74.34	21.54
Bromide	0.20 U	0.20 U	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U		0.20 U									0.43			0.36	0.67	0.20 U	0.33
Nitrate as N	0.05 J	0.20 U	0.20 U		0.20 U	0.14 J	0.12 J	0.01 J		0.20 U									0.02 J			0.20 U	0.03 J	0.12 J	0.20 U
Phosphate as P, ortho	0.12 J	0.20 U	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U		0.20 U									0.20 U			0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS																									
pH (SU)	6.97	6.86	6.68	6.78	6.69	6.68	6.85	6.84	6.82	6.76	6.83	6.83	6.74	6.77	6.92	6.92	6.84	6.86	6.91	6.98	6.94	7.00	6.95	7.06	7.3
Temperature (°C)	24.08	21.97	23.00	27.30	23.90	24.27	17.88	21.6	21.31	19.6	18.3	22.3	21.3	20.9	14.4	17.7	21	17.2	19.4	22.8	21.4	19	22.4	23.8	19.1
Dissolved Oxygen (DO; mg/L)	0.64	0.86	4.8	0.32	3.54	2.92	0.8	8.11	4.43	2.73	3.31	6.08	5.25	2.35	0.91	7.87	3.96	8.74	7.15	0.78	5.3	7.74	9.55	10.22	0.02
Redox Potential (ORP; mV)	-90.6	33.5	-14.5	-41.2	57.1	113.0	117.6	70	62.1	21.1	128.4	151.1	158.7	118.1	77.3	127.3	138.2	127.8	143	107.4	151.8	151.4	170.5	78.1	-51.3
Specific Conductivity (mS/cm)	0.640	1.128	1.102	0.997	0.979	0.912	0.977	0.982	0.952	0.874	0.878	0.944	0.946	0.929	0.76	0.772	0.802	0.753	0.684	0.655	0.815	0.959	0.822	0.815	0.554
Depth to Water (ft-btoc) prior to purging	7.6	7.79	6.35	7.78	7.94	7.84	7.41	7.34	7.3	7.42	7.14	7.24	7.3	7.33	7.51	7.67	7.63	6.86	6.81	7.22	7.55	7.84	6.88	7.91	7.50
Purge Rate (mL/min)	180	200	280	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)	9.00E-01 J		4.80E+00 U																			2.22E+03		1.43E+03	
Propane Monooxygenase (PPO)	5.30E+00		4.58E+01																			1.89E+04		4.50E+04	
Ammonia Monooxygenase (AMO)	4.90E+00 U		2.00E-01 J																			3.00E-01 J		7.30E+00	
Soluble Methane Monooxygenase (SMMO)	4.90E+00 U		5.27E+02																			4.80E+00 U		4.60E+00 U	
Particulate methane monooxygenase (PMMO)	4.90E+00 U		4.80E+00 U																			4.80E+00 U		3.70E+00 J	
Ethene Monooxygenase (EtnC)	4.90E+00 U		4.80E+00 U																			4.80E+00 U		4.60E+00 U	
Epoxyalkane transferase (EtnE)	4.90E+00 U		4.80E+00 U																			4.80E+00 U		1.09E+02	

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4
Sampling Date	7/17/2019	8/29/2019	10/2/2019	10/9/2019	10/16/2019	10/23/2019	11/11/2019	11/20/2019	12/9/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/12/2020	7/13/2020	9/16/2020	12/22/2020
Days	-6	37	71	78	85	92	111	120	139	163	174	175	177	181	189	196	204	217	240	268	294	356	421	518
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
VOCS (GC/MS)	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
dichlorodifluoromethane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloromethane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
vinyl chloride	4.64	1.61				1.84	1.2		3.37	0.98 J				1.15			0.67 J	1.00 U		1.24	0.94 J	0.74 J	1.00 U	25.65
bromomethane	2.00 U	2.00 U				2.00 U	2.0 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
chloroethane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	0.94 J
trichlorofluoromethane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethylene	0.15 J	1.00 U				0.18 J	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
methylene chloride	2.00 U	2.00 U				2.00 U	2.0 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
trans-1,2-dichloroethylene	1.13	1.99				0.55 J	1.0 U		0.92 J	0.78 J				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethane	0.06 J	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2,2-dichloropropane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis 1,2- dichloroethylene	86.83	87.04				74.11	84.7		77.76	90.16				52.37			37.53	37.31		19.96	16.42	11.59	9.19	84.51
bromochloromethane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloroform	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,1-trichloroethane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
carbon tetrachloride	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloropropene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
benzene	0.56 J	0.56 J				0.50 J	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	0.70 J
1,2-dichloroethane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trichloroethylene	1.00 U	1.00 U				1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichloropropane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromomethane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromodichloromethane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis-1,3-dichloropropene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
toluene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trans-1,3-dichloropropene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2-trichloroethane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tetrachloroethylene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichloropropane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromochloromethane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromoethane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chlorobenzene	2.27	1.93				1.73	1.6		1.68	1.58				1.88			1.02	0.90 J		1.00 U	1.00 U	1.00 U	1.00 U	2.95
1,1,1,2-tetrachloroethane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
ethylbenzene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
xylenes (m/p)	2.00 U	2.00 U				2.00 U	2.0 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
o-xylene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
styrene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromoform	2.00 U	2.00 U				2.00 U	2.0 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
isopropyl benzene (cumene)	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromobenzene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2,2-tetrachloroethane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichloropropane	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
n-propyl benzene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2-chlorotoluene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-chlorotoluene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3,5-trimethylbenzene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tert-butylbenzene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,4-trimethylbenzene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
sec-butylbenzene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichlorobenzene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-isopropyltoluene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,4-dichlorobenzene	0.11 J	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichlorobenzene	1.52	1.15				1.22	1.3		1.21	1.29				1.43			1.34	1.39		0.94 J	1.00 U	1.00 U	1.00 U	2.14
n-butylbenzene	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromo-3-chloropropane	2.00 U	2.00 U				2.00 U	2.0 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
1,2,4-trichlorobenzene	0.15 J	1.00 U				1.00 U	1.0 U		0.78 J	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
hexachlorobutadiene	1.00 U	1.00 U				1.00 U	1.0 U		0.72 J	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
naphthalene	0.27 J	1.00 U				1.00 U	1.0 U		1.48	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichlorobenzene	0.27 J	1.00 U				1.00 U	1.0 U		0.95 J	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Methyl tertiary butyl ether	1.00 U	1.00 U				1.00 U	1.0 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Acetone	5.00 U	5.00 U				5.00 U	5.0 U		4.37 J	5.00 U				2.90			5.00 U	5.00 U		5.00 U	5.00 U	3.05	5.00 U	5.00 U
carbon disulfide	2.00 U	2.00 U				2.00 U	2.0 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
2-butanone (MEK)	5.00 U	5.00 U				5.00 U	5.0 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
tetrahydrofuran (THF)	5.00 U	5.00 U				5.00 U	5.0 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
4-methyl-2-pentanone (MIBK)	5.00 U	5.00 U				5.00 U	5.0 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-hexanone	5.00 U	5.00 U				5.00 U	5.0 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-chloroethyl vinyl ether	5.00 U	5.00 U				5.00 U	5.0 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U

Sample ID	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4	PMW-1-4
Sampling Date	7/17/2019	8/29/2019	10/2/2019	10/9/2019	10/16/2019	10/23/2019	11/11/2019	11/20/2019	12/9/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/12/2020	7/13/2020	9/16/2020	12/22/2020
Days	-6	37	71	78	85	92	111	120	139	163	174	175	177	181	189	196	204	217	240	268	294	356	421	518
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.96	1.36				1.02			1.70									2.33				1.27	1.32	2.69
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	369.37	2.10	23.29	3.37	2.59	7.33	4.50	2.49	43.98	15.62	3.01	1.91	13.48	24.42	3.11	2.00	3.13	52.34	14.04	16.69	17.51	10.46	1.41	327.98
Ethane	0.51 J	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	0.75 J	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U
Propane	2.13 J	2.68 U	495.19	610.16	1660.61	291.24	20.45	684.90	1770.97	40.97	103.25	66.38	70.68	37.44	82.76	123.28	28.37	84.12	13.62	18.69	31.93	79.07	8.89	2.68 U
Acetylene	2.31 J	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.161	0.02	0.09	0.02	0.03	0.08	0.06	0.11	0.01 J	0.08	0.17	0.18	0.13	0.14	0.09	0.11	0.05	0.11	0.19	0.10	0.07	0.05	0.13	0.28
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	13.45	14.07		13.98	16.58	16.52	18.11		16.53									15.16			14.82	15.06	15.47	19.15
Nitrite as N	0.20 U	0.20 U		0.20 U	0.09 J	0.10 J	0.08 J		0.20 U									0.20 U			0.20 U	0.20 U	0.20 U	0.04 J
Sulfate as SO4	16.37	374.05 D		130.15 D	183.04 D	191.71 D	129.77 D		81.44									48.79			38.65	54.43	42.40	19.68
Bromide	0.72	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U		0.20 U									0.25			0.31	0.52	0.43	0.20 U
Nitrate as N	0.20 U	0.20 U		0.20 U	0.02 J	0.10 J	0.20 U		0.01 J									0.01 J			0.03 J	0.02 J	0.04 J	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U		0.20 U									0.20 U			0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS																								
pH (SU)	6.97	6.88	6.80	6.80	6.76	6.82	6.84	6.86	6.8	6.85	6.87	6.84	6.86	6.93	6.95	6.88	6.94	6.88	7.02	6.97	7.02	7	7.11	7.31
Temperature (^{o}C)	23.40	22.37	26.88	23.66	23.88	18.80	21.47	20.88	19.4	18.2	21.4	20.9	19.3	13.1	18	20.5	17	19.5	22.9	21.7	20.3	23.1	24.6	18.9
Dissolved Oxygen (DO; mg/L)	0.57	5.41	1.6	10.37	10.36	3.16	16.22	15.92	3.24	12.57	17.11	13.97	8.84	4.56	14.56	13.91	12.7	14.22	2.87	4.04	6.84	12.09	11.19	0.01
Redox Potential (ORP; mV)	-103.3	55.3	15.8	147.0	167.0	113.5	123.9	175	61.3	170.7	168	218.7	164.5	117.9	157.7	177.8	171.8	180	67.3	147.5	149.1	139.8	77.9	-109.3
Specific Conductivity (mS/cm)	0.532	1.109	0.781	0.753	0.793	0.964	0.854	0.801	0.774	0.754	0.768	0.799	0.833	0.699	0.664	0.688	0.669	0.713	0.577	0.679	0.827	0.725	0.728	0.532
Depth to Water (ft-btoc) prior to purging	7.7	7.9	7.87	8.04	7.94	7.50	7.46	7.34	7.53	7.24	7.24	7.41	7.44	7.64	7.78	7.72	7	6.94	7.32	7.65	7.91	6.99	8	7.61
Purge Rate (mL/min)	220	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)																								
Propane Monooxygenase (PPO)																								
Ammonia Monooxygenase (AMO)																								
Soluble Methane Monooxygenase (SMMO)																								
Particulate methane monooxygenase (PMMO)																								
Ethene Monooxygenase (EtnC)																								
Epoxyalkane transferase (EtnE)																								

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-2-1		PMW-2-1		PMW-2-1		PMW-2-1		PMW-2-1		PMW-2-1		PMW-2-1		PMW-2-1		PMW-2-1	
Sampling Date	7/18/2019		8/27/2019		10/24/2019		12/9/2019		2/25/2020		5/11/2020		7/14/2020		9/17/2020		12/21/2020	
Days	-5		35		93		139		217		293		357		422		517	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
dichlorodifluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	1.00	U	1.08		1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.61	J
bromomethane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichlorofluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
methylene chloride	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	0.83	J	0.81	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.63	J
1,1-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	38.38		32.38		19.06		25.97		2.33		1.00	U	1.44		0.58	J	28.70	
bromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chlorobenzene	1.33		1.03		1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.96	J
1,1,1,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-isopropyltoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,4-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichlorobenzene	1.00	U	0.61	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.73	J
n-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
hexachlorobutadiene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
naphthalene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Acetone	5.00	U	5.00	U	5.00	U	1.14	J	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-hexanone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	PMW-2-1	PMW-2-1	PMW-2-1	PMW-2-1	PMW-2-1	PMW-2-1	PMW-2-1	PMW-2-1	PMW-2-1
Sampling Date	7/18/2019	8/27/2019	10/24/2019	12/9/2019	2/25/2020	5/11/2020	7/14/2020	9/17/2020	12/21/2020
Days	-5	35	93	139	217	293	357	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	0.74								
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	144.08	25.02	2.32	20.63	14.98	0.95 U	7.36	0.78 J	80.22
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U
Propane	2.68 U	2.68 U	275.94	1693.62	1.44 J	87.60	351.70	2.68 U	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.168	0.020 U	0.01 J	0.03	0.05	0.03	0.02	0.04	0.25
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	29.25	26.61	31.75	30.08	29.41	26.24	29.76	24.20	29.84
Nitrite as N	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.05 J
Sulfate as SO4	24.35	367.31 D	242.56 D	114.71 D	92.82	96.04	117.60 D	152.23 D	29.41
Bromide	0.20 U	0.20 U	0.20 U	0.20 U	0.25	0.20 U	0.20 U	0.20 U	0.20 U
Nitrate as N	0.03 J	0.20 U	0.12 J	0.20 U	0.02 J	0.20 U	0.20 U	0.05 J	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS									
pH (SU)	6.95	6.68	6.77	7.36	7.11	6.93	7.05	7.16	7.07
Temperature (^{o}C)	23.17	23.4	20.29	20.90	19.70	24.70	20.70	22.27	20
Dissolved Oxygen (DO; mg/L)	0.67	1.26	0.2	2.97	3.77	0.93	0.82	7.01	0.59
Redox Potential (ORP; mV)	-85.5	-36.7	19.1	-25.8	131.2	52.2	1.2	50.7	10.5
Specific Conductivity (mS/cm)	0.590	1.327	1.071	0.760	0.635	0.963	0.831	0.942	0.549
Depth to Water (ft-btoc) prior to purging	7.5	7.99	7.4	7.30	6.72	7.69	6.52	7.62	7.59
Purge Rate (mL/min)	240	220	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)									
Propane Monooxygenase (PPO)									
Ammonia Monooxygenase (AMO)									
Soluble Methane Monooxygenase (SMMO)									
Particulate methane monooxygenase (PMMO)									
Ethene Monooxygenase (EtnC)									
Epoxyalkane transferase (EtnE)									

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero.
The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2
Sampling Date	7/17/2019	8/27/2019	10/24/2019	11/20/2019	12/9/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/11/2020	7/14/2020	9/17/2020	12/21/2020
Days	-6	35	93	120	139	163	174	175	177	181	189	196	204	217	240	268	293	357	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
VOCS (GC/MS)	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
dichlorodifluoromethane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloromethane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
vinyl chloride	12.63	4.47	6.01		13.97	17.13				2.67			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	37.29
bromomethane	2.00 U	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
chloroethane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	0.95 J
trichlorofluoromethane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethylene	0.36 J	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
methylene chloride	2.00 U	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
trans-1,2-dichloroethylene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2,2-dichloropropane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis 1,2- dichloroethylene	74.95	45.59	64.73		65.26	71.75				51.59			13.80	6.58		1.78	1.00 U	1.00 U	1.85	57.78
bromochloromethane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloroform	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,1-trichloroethane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
carbon tetrachloride	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloropropene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
benzene	0.94 J	1.00 U	0.76 J		0.87 J	0.97 J				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	0.79 J
1,2-dichloroethane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trichloroethylene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichloropropane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromomethane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromodichloromethane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis-1,3-dichloropropene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
toluene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trans-1,3-dichloropropene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2-trichloroethane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tetrachloroethylene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichloropropane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromochloromethane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromoethane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chlorobenzene	4.68	2.00	2.73		3.41	3.05				2.80			0.81 J	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	2.99
1,1,1,2-tetrachloroethane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
ethylbenzene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
xylenes (m/p)	2.00 U	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
o-xylene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
styrene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromoform	2.00 U	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
isopropyl benzene (cumene)	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromobenzene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2,2-tetrachloroethane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichloropropane	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
n-propyl benzene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2-chlorotoluene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-chlorotoluene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3,5-trimethylbenzene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tert-butylbenzene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,4-trimethylbenzene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
sec-butylbenzene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichlorobenzene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-isopropyltoluene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,4-dichlorobenzene	0.27 J	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichlorobenzene	2.92	1.49	1.77		2.33	2.22				2.70			2.12	1.57		1.80	1.00 U	1.00 U	1.00 U	1.93
n-butylbenzene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromo-3-chloropropane	2.00 U	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
1,2,4-trichlorobenzene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
hexachlorobutadiene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
naphthalene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichlorobenzene	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Methyl tertiary butyl ether	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Acetone	5.00 U	5.00 U	5.00 U		5.00 U	5.00 U				6.51			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
carbon disulfide	2.00 U	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
2-butanone (MEK)	5.00 U	5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
tetrahydrofuran (THF)	5.00 U	5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
4-methyl-2-pentanone (MIBK)	5.00 U	5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-hexanone	5.00 U	5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-chloroethyl vinyl ether	5.00 U	5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U

Sample ID	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2	PMW-2-2
Sampling Date	7/17/2019	8/27/2019	10/24/2019	11/20/2019	12/9/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/11/2020	7/14/2020	9/17/2020	12/21/2020
Days	-6	35	93	120	139	163	174	175	177	181	189	196	204	217	240	268	293	357	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.29																			
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	248.52	6.73	2.68	4.44	184.43	166.57	3.27	2.17	1.76	2.83	3.02	1.03	0.69 J	7.12	0.97	0.50 J	0.95 U	2.87	1.07	284.10
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	0.50 J	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	0.69 J	2.22 U	2.22 U	2.22 U	2.22 U	0.63 J	2.22 U	2.22 U	2.22 U	2.22 U	0.55 J	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	0.51 J
Propane	2.68 U	2.68 U	19.46	9.11	1723.67	1.79 J	2.34 J	1.96 J	17.35	1026.12	86.96	545.70	8.83	0.91 J	2.68 U	32.52	4.26	4.60	29.48	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.168	0.020 U	0.06	0.02	0.40	0.15	0.14	0.15	0.12	13.40 D	0.83 D	4.80 D	6.80 D	0.40	0.30	0.29	8.60 D	2.20 D	23.50 D	0.50 D
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	18.41	20.83	16.14		16.66									18.46			16.57	20.67	21.57	16.83
Nitrite as N	0.20 U	0.20 U	0.20 U		0.20 U									0.20 U			0.20 U	0.20 U	0.23	0.20 U
Sulfate as SO4	34.40	308.32 D	227.77 D		48.37									92.60			74.74	70.07	48.99	22.81
Bromide	0.20 U	0.20 U	0.20 U		0.20 U									0.28			0.29	0.43	0.20 U	0.20 U
Nitrate as N	0.02 J	0.20 U	0.09 J		0.20 U									0.20 U			0.20 U	0.20 U	0.04 J	0.20 U
Phosphate as P, ortho	0.11 J	0.20 U	0.20 U		0.20 U									0.20 U			0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS																				
pH (SU)	6.96	6.91	6.89	6.83	7.48	6.95	6.84	6.85	6.87	7.12	7.11	6.97	6.97	6.99	7.04	6.94	6.96	7.33	6.80	7.03
Temperature (^{o}C)	25.48	22.5	20.16	21.26	20.90	18.40	19.90	22.5	22.5	14.9	18.6	20	17.1	19.8	22.6	21.7	24.9	20.3	21.54	20
Dissolved Oxygen (DO; mg/L)	0.87	0.16	0.1	0.28	0.41	0.04	0.09	0.13	0.1	0.32	0.14	0	0.06	0.2	0	0.13	0.09	0.97	1.13	0.08
Redox Potential (ORP; mV)	-108.8	-105.3	-45.6	-95.5	-85.7	-66.7	-65.2	-54.4	-57.6	-44.9	-84.3	-72.7	-52.3	4.4	-69.6	-49.9	-36.9	-0.428	44.7	10
Specific Conductivity (mS/cm)	0.545	1.131	1.044	0.958	0.650	0.671	0.847	0.862	0.815	0.661	0.720	0.723	0.695	0.627	0.689	0.778	0.956	0.775	0.745	0.59
Depth to Water (ft-btoc) prior to purging	7.5	8.05	7.41	7.30	7.32	7.11	7.24	7.24	7.28	7.43	7.63	7.54	6.81	6.77	7.14	7.44	7.71	6.56	7.66	7.64
Purge Rate (mL/min)	200	220	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)																				
Propane Monooxygenase (PPO)																				
Ammonia Monooxygenase (AMO)																				
Soluble Methane Monooxygenase (SMMO)																				
Particulate methane monooxygenase (PMMO)																				
Ethene Monooxygenase (EtnC)																				
Epoxyalkane transferase (EtnE)																				

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3
Sampling Date	7/17/2019	8/27/2019	10/24/2019	11/11/2019	11/20/2019	12/9/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/11/2020	7/14/2020	9/17/2020	12/21/2020
Days	-6	35	93	111	120	139	163	174	175	177	181	189	196	204	217	240	268	293	357	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
VOCS (GC/MS)	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
dichlorodifluoromethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloromethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
vinyl chloride	12.55	4.70	3.92	3.24		14.22	3.46				1.69			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	48.68
bromomethane	2.00 U	2.00 U	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
chloroethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	2.32
trichlorofluoromethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethylene	0.13 J	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
methylene chloride	2.00 U	2.00 U	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
trans-1,2-dichloroethylene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2,2-dichloropropane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis 1,2- dichloroethylene	67.58	58.43	61.95	65.05		71.55	40.29				31.28			1.08	1.02		1.00 U	1.00 U	1.00 U	1.00 U	56.77
bromochloromethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloroform	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,1-trichloroethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
carbon tetrachloride	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloropropene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
benzene	0.62 J	1.00 U	1.00 U	1.00 U		0.89 J	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	0.84 J
1,2-dichloroethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trichloroethylene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichloropropane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromomethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromodichloromethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis-1,3-dichloropropene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
toluene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trans-1,3-dichloropropene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2-trichloroethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tetrachloroethylene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichloropropane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromochloromethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromoethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chlorobenzene	3.88	2.30	2.98	2.67		3.62	1.53				1.71			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	3.16
1,1,1,2-tetrachloroethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
ethylbenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
xylenes (m/p)	2.00 U	2.00 U	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
o-xylene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
styrene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromoform	2.00 U	2.00 U	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
isopropyl benzene (cumene)	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromobenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2,2-tetrachloroethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichloropropane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
n-propyl benzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2-chlorotoluene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-chlorotoluene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3,5-trimethylbenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tert-butylbenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,4-trimethylbenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
sec-butylbenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichlorobenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-isopropyltoluene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,4-dichlorobenzene	0.24 J	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichlorobenzene	2.38	1.73	1.96	1.96		2.67	2.11				2.84			1.75	2.08		0.82 J	1.00 U	1.00 U	1.00 U	2.71
n-butylbenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromo-3-chloropropane	2.00 U	2.00 U	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
1,2,4-trichlorobenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
hexachlorobutadiene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
naphthalene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichlorobenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Methyl tertiary butyl ether	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Acetone	0.24 J	5.00 U	5.00 U	5.00 U		3.38 J	5.00 U				2.38			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
carbon disulfide	2.00 U	2.00 U	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
2-butanone (MEK)	5.00 U	5.00 U	5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
tetrahydrofuran (THF)	5.00 U	5.00 U	5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
4-methyl-2-pentanone (MIBK)	5.00 U	5.00 U	5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-hexanone	5.00 U	5.00 U	5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-chloroethyl vinyl ether	5.00 U	5.00 U	5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U

Sample ID	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3	PMW-2-3
Sampling Date	7/17/2019	8/27/2019	10/24/2019	11/11/2019	11/20/2019	12/9/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/11/2020	7/14/2020	9/17/2020	12/21/2020
Days	-6	35	93	111	120	139	163	174	175	177	181	189	196	204	217	240	268	293	357	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.56																				
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	339.89	16.03	4.60	2.60	1.97	33.08	16.00	1.18	0.77 J	0.97	6.04	1.08	0.85 J	0.40 J	4.60	2.70	0.24 J	0.95 U	5.00	0.92 J	371.69
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	0.70 J	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	0.45 J
Propane	2.68 U	2.68 U	346.11	17.65	458.60	2398.24	1.44 J	28.06	282.46	120.63	56.43	8.93	44.50	1.32 J	3.21	2.76	6.74	2.68 U	6.76	2.68 U	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.154	0.02 U	9.00 D	3.20 D	0.06	0.44	0.26	0.15	0.22	0.16	0.10	1.02 D	3.40 D	3.00 D	4.20 D	1.00 D	1.40 D	3.20 D	8.00 D	1.80 D	0.70 D
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	17.60	16.78	15.04	15.05		14.42									16.38			16.14	16.95	16.42	14.95
Nitrite as N	0.20 U	0.20 U	0.20 U	0.09 J		0.20 U									0.20 U			0.23	1.81	1.32	0.20 U
Sulfate as SO4	25.68	475.63 D	221.78 D	204.14 D		124.94 D									87.41			107.90 D	81.31	72.93	21.06
Bromide	0.20 U	0.20 U	0.20 U	0.20 U		0.20 U									0.37			0.34	0.43	0.20 U	0.35
Nitrate as N	0.04 J	0.20 U	0.03 J	0.01 J		0.20 U									0.06 J			0.67	0.14 J	0.93	0.20 U
Phosphate as P, ortho	0.11 J	0.20 U	0.20 U	0.20 U		0.20 U									0.20 U			0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS																					
pH (SU)	6.95	6.65	6.81	6.81	6.80	7.29	6.88	6.53	6.82	6.83	6.99	6.91	6.91	6.96	6.97	6.97	6.95	6.90	7.10	6.53	6.99
Temperature (^{o}C)	23.66	22.3	20.59	21.90	20.99	20.30	18.30	21.8	22.5	21.1	15.1	18.7	19.9	17.5	19.7	23.3	22	24.4	20.3	21.14	19.5
Dissolved Oxygen (DO; mg/L)	0.57	8.35	0.2	11.98	6.88	2.80	5.62	6.60	5.24	4.12	1.27	12.49	4.32	4.67	8.79	0.22	3.43	8.45	5.36	7.85	0.13
Redox Potential (ORP; mV)	-100.2	25.9	15.8	100.2	108.8	-12.1	136.6	165.7	157	150.4	69.1	123	116.9	102.4	153.3	41.6	114.2	113.4	81.1	12.6	13.4
Specific Conductivity (mS/cm)	0.543	1.501	1.015	1.026	1.006	0.790	0.807	0.927	0.943	0.909	0.698	0.761	0.795	0.763	0.737	0.62	0.817	1.014	0.829	0.843	0.6
Depth to Water (ft-btoc) prior to purging	7.5	8	7.37	7.24	7.21	7.28	7.01	7.17	7.21	7.23	7.38	7.57	7.5	6.77	6.71	7.07	7.41	7.67	6.48	7.6	7.58
Purge Rate (mL/min)	200	250	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)																					
Propane Monooxygenase (PPO)																					
Ammonia Monooxygenase (AMO)																					
Soluble Methane Monooxygenase (SMMO)																					
Particulate methane monooxygenase (PMMO)																					
Ethene Monooxygenase (EtnC)																					
Epoxyalkane transferase (EtnE)																					

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4
Sampling Date	7/18/2019	8/28/2019	10/23/2019	11/11/2019	11/20/2019	12/9/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/12/2020	7/14/2020	9/17/2020	12/21/2020
Days	-5	36	92	111	120	139	163	174	175	177	181	189	196	204	217	240	268	294	357	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
VOCS (GC/MS)	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
dichlorodifluoromethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloromethane	1.00 U	0.03 J	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
vinyl chloride	3.99	5.37	2.71	3.13		2.78	4.43				1.35			1.00 U	1.00 U		1.21	1.00 U	1.00 U	1.00 U	22.05
bromomethane	2.00 U	0.08 J	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
chloroethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trichlorofluoromethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethylene	1.00 U	0.22 J	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
methylene chloride	2.00 U	2.00 U	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
trans-1,2-dichloroethylene	1.10	1.40	0.53 J	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethane	1.00 U	0.12 J	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2,2-dichloropropane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis 1,2- dichloroethylene	82.76	86.00	82.81	64.58		77.43	102.95				60.87			32.79	31.88		16.14	2.99	1.68	0.82 J	67.90
bromochloromethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloroform	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,1-trichloroethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
carbon tetrachloride	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloropropene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
benzene	1.00 U	0.60 J	1.00 U	1.00 U		1.00 U	0.94 J				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	0.54 J
1,2-dichloroethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trichloroethylene	1.00 U	0.08 J	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichloropropane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromomethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromodichloromethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis-1,3-dichloropropene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
toluene	1.00 U	0.02 J	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trans-1,3-dichloropropene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2-trichloroethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tetrachloroethylene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichloropropane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromochloromethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromoethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chlorobenzene	1.86	2.18	1.87	1.56		1.73	2.74				2.24			1.09	0.92 J		1.00 U	1.00 U	1.00 U	1.00 U	2.48
1,1,1,2-tetrachloroethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
ethylbenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
xylenes (m/p)	2.00 U	2.00 U	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
o-xylene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
styrene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromoform	2.00 U	2.00 U	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
isopropyl benzene (cumene)	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromobenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2,2-tetrachloroethane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichloropropane	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
n-propyl benzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2-chlorotoluene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-chlorotoluene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3,5-trimethylbenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tert-butylbenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,4-trimethylbenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
sec-butylbenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichlorobenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-isopropyltoluene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,4-dichlorobenzene	1.00 U	0.12 J	0.08 J	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichlorobenzene	1.31	1.49	1.35	1.00		1.15	1.42				1.81			1.29	1.34		0.84 J	1.00 U	1.00 U	1.00 U	1.69
n-butylbenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromo-3-chloropropane	2.00 U	2.00 U	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
1,2,4-trichlorobenzene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
hexachlorobutadiene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
naphthalene	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichlorobenzene	0.70 J	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Methyl tertiary butyl ether	1.00 U	1.00 U	1.00 U	1.00 U		1.00 U	1.00 U				1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Acetone	5.00 U	9.38	7.90	5.00 U		4.70 J	5.00 U				2.21			5.00 U	5.00 U		5.00 U	5.00 U	4.99	5.00 U	5.00 U
carbon disulfide	2.00 U	0.04 J	2.00 U	2.00 U		2.00 U	2.00 U				2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
2-butanone (MEK)	5.00 U	0.45 J	5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
tetrahydrofuran (THF)	5.00 U	0.23 J	5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
4-methyl-2-pentanone (MIBK)	5.00 U	5.00 U	5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-hexanone	5.00 U	0.43 J	5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-chloroethyl vinyl ether	5.00 U	5.00 U	5.00 U	5.00 U		5.00 U	5.00 U				5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U

Sample ID	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4	PMW-2-4
Sampling Date	7/18/2019	8/28/2019	10/23/2019	11/11/2019	11/20/2019	12/9/2019	1/2/2020	1/13/2020	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/25/2020	3/19/2020	4/16/2020	5/12/2020	7/14/2020	9/17/2020	12/21/2020
Days	-5	36	92	111	120	139	163	174	175	177	181	189	196	204	217	240	268	294	357	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.89	1.70	1.11			1.48									2.33				0.90 J	1.67	2.62
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	460.96	22.68	3.14	23.48	16.10	19.32	37.35	10.60	5.86	4.38	4.42	1.82	2.17	0.60 J	14.26	15.00	12.48	0.95 U	3.28	1.23	240.46
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	0.71 J	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U
Propane	2.68 U	2.68 U	616.04	50.17	32.12	2928.28	90.94	17.93	10.43	12.81	172.26	179.51	146.24	24.38	88.99	5.28	11.01	12.08	226.76	2.18 J	2.68 U
Acetylene	1.82 J	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.098	0.02	0.02 U	0.01 J	0.01 J	0.02 U	0.07	0.12	0.12	0.11	0.14	0.09	0.08	0.05	0.06	0.11	0.10	0.03	0.02	0.13	0.31
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	13.88	12.65	16.72	17.64		18.23									15.15			14.75	14.95	15.72	19.70
Nitrite as N	0.20 U	0.20 U	0.07 J	0.10 J		0.20 U									0.20 U			0.20 U	0.20 U	0.20 U	0.20 U
Sulfate as SO4	16.83	551.23 D	266.56 D	168.21 D		97.24									81.79			73.54	95.55	66.97	20.06
Bromide	0.67	0.20 U	0.20 U	0.20 U		0.20 U									0.38			0.41	0.47	0.20 U	0.20 U
Nitrate as N	0.02 J	0.20 U	0.20 U	0.20 U		0.20 U									0.02 J			0.20 U	0.20 U	0.03 J	0.20 U
Phosphate as P, ortho	0.11 J	0.20 U	0.20 U	0.20 U		0.20 U									0.20 U			0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS																					
pH (SU)	6.98	6.6	6.72	6.80	6.83	7.33	6.84	6.84	6.83	6.83	6.93	6.83	6.84	6.89	6.93	6.9	6.95	7.01	7.06	6.55	7.03
Temperature (°C)	23.27	21.3	19.53	22.49	19.00	19.90	18.10	21	21.7	19.9	14.4	18.7	19.2	17.8	19.2	22.6	22.3	21.3	20.4	21.13	19.3
Dissolved Oxygen (DO; mg/L)	0.49	0.5	0.3	0.81	0.41	0.98	0.04	0.21	0.31	0.28	0.27	0.15	0	0.91	1.1	0.77	0.65	1.36	4.7	7.21	0.09
Redox Potential (ORP; mV)	-87.1	-68.8	0.2	-46.7	-61.8	-81.3	-55.7	-42.4	-31.7	-27	-35.3	-29.7	-25.7	-27.3	3.5	-10.7	21.1	26.2	14.9	-15.9	-7.6
Specific Conductivity (mS/cm)	0.606	1.642	1.181	0.967	0.902	0.760	0.877	0.922	0.964	0.980	0.793	0.799	0.771	0.718	0.739	0.629	0.763	0.928	0.829	0.789	0.57
Depth to Water (ft-btoc) prior to purging	7.4	7.87	7.17	7.11	7.07	7.16	6.94	6.91	7.07	7.12	6.7	7.44	7.36	6.64	6.57	6.96	7.31	7.6	6.38	7.48	7.48
Purge Rate (mL/min)	200	260	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)																					
Propane Monooxygenase (PPO)																					
Ammonia Monooxygenase (AMO)																					
Soluble Methane Monooxygenase (SMMO)																					
Particulate methane monooxygenase (PMMO)																					
Ethene Monooxygenase (EtnC)																					
Epoxyalkane transferase (EtnE)																					

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-3-1		PMW-3-1		PMW-3-1		PMW-3-1		PMW-3-1		PMW-3-1		PMW-3-1		PMW-3-1		PMW-3-1	
Sampling Date	7/18/2019		8/28/2019		10/24/2019		12/9/2019		2/26/2020		5/11/2020		7/14/2020		9/17/2020		12/21/2020	
Days	-5		36		93		139		218		293		357		422		517	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
dichlorodifluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	0.36	J	0.84	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.40	J
bromomethane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichlorofluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
methylene chloride	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	0.47	J	0.80	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	28.29		28.43		14.65		21.28		3.01		0.84	J	2.11		1.00	U	17.80	
bromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	0.37	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	0.11	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chlorobenzene	0.96	J	0.82	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.65	J
1,1,1,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-isopropyltoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,4-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichlorobenzene	0.37	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
hexachlorobutadiene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
naphthalene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.18		1.00	U
1,2,3-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Acetone	5.00	U	5.00	U	5.00	U	1.86	J	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-hexanone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	PMW-3-1	PMW-3-1	PMW-3-1	PMW-3-1	PMW-3-1	PMW-3-1	PMW-3-1	PMW-3-1	PMW-3-1
Sampling Date	7/18/2019	8/28/2019	10/24/2019	12/9/2019	2/26/2020	5/11/2020	7/14/2020	9/17/2020	12/21/2020
Days	-5	36	93	139	218	293	357	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	0.82								
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	116.67	16.71	1.58	17.90	10.08	0.95 U	11.48	0.39 J	51.84
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U
Propane	2.68 U	2.68 U	402.82	1171.62	3.10	77.07	181.53	1.37 J	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.119	0.02 U	0.01 J	0.02 U	0.08	0.03	0.02	0.04	0.23
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	27.39	23.17	29.83	28.05	27.56	23.72	23.81	21.76	27.01
Nitrite as N	0.20 U	0.20 U	0.02 J	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.02 J
Sulfate as SO4	23.61	402.13 D	204.86 D	96.01	72.68	70.77	86.60	135.21 D	22.57
Bromide	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.28	0.20 U	0.20 U	0.20 U
Nitrate as N	0.02 J	0.20 U	0.02 J	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.01 J
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS									
pH (SU)	7.03	6.69	6.81	7.37	7.15	7.01	7.15	6.86	6.71
Temperature (^{o}C)	24.64	23.3	21.88	21.00	17.80	24.30	21.80	22.64	19
Dissolved Oxygen (DO; mg/L)	0.34	0.14	0.1	0.46	0.31	0.07	0.04	4.99	0.2
Redox Potential (ORP; mV)	-103.4	-68.9	-22.7	-71.8	-60.2	-29.1	-30.3	-15	34.2
Specific Conductivity (mS/cm)	0.527	1.350	0.945	0.700	0.693	0.624	0.726	0.823	0.480
Depth to Water (ft-btoc) prior to purging	7.3	7.81	7.21	7.14	6.46	7.51	6.33	7.33	7.38
Purge Rate (mL/min)	200	250	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)									
Propane Monooxygenase (PPO)									
Ammonia Monooxygenase (AMO)									
Soluble Methane Monooxygenase (SMMO)									
Particulate methane monooxygenase (PMMO)									
Ethene Monooxygenase (EtnC)									
Epoxyalkane transferase (EtnE)									

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2
Sampling Date	7/18/2019	8/28/2019	10/24/2019	12/9/2019	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/26/2020	3/19/2020	4/16/2020	5/11/2020	7/14/2020	9/17/2020	12/21/2020
Days	-5	36	93	139	175	177	181	189	196	204	218	240	268	293	357	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
VOCS (GC/MS)	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
dichlorodifluoromethane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloromethane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
vinyl chloride	10.58	5.76	3.96	15.94			1.36			0.68 J	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	39.77
bromomethane	2.00 U	2.00 U	2.00 U	2.00 U			2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
chloroethane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trichlorofluoromethane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethylene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
methylene chloride	2.00 U	2.00 U	2.00 U	2.00 U			2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
trans-1,2-dichloroethylene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloroethane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2,2-dichloropropane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis 1,2- dichloroethylene	62.82	53.78	50.63	65.55			50.28			28.20	5.27		8.18	3.99	7.61	1.11	55.72
bromochloromethane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chloroform	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,1-trichloroethane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
carbon tetrachloride	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1-dichloropropene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
benzene	0.79 J	0.55 J	1.00 U	0.97 J			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	0.76 J
1,2-dichloroethane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trichloroethylene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichloropropane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromomethane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromodichloromethane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
cis-1,3-dichloropropene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
toluene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
trans-1,3-dichloropropene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2-trichloroethane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tetrachloroethylene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichloropropane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
dibromochloromethane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromoethane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
chlorobenzene	3.95	2.38	2.29	3.53			2.96			1.63	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	2.79
1,1,1,2-tetrachloroethane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
ethylbenzene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
xylenes (m/p)	2.00 U	2.00 U	2.00 U	2.00 U			2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
o-xylene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
styrene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromoform	2.00 U	2.00 U	2.00 U	2.00 U			2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
isopropyl benzene (cumene)	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
bromobenzene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,1,2,2-tetrachloroethane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,3-trichloropropane	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
n-propyl benzene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
2-chlorotoluene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-chlorotoluene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3,5-trimethylbenzene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
tert-butylbenzene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2,4-trimethylbenzene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
sec-butylbenzene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,3-dichlorobenzene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-isopropyltoluene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,4-dichlorobenzene	0.22 J	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dichlorobenzene	2.39	1.66	1.62	2.48			2.55			2.33	2.92		2.14	1.32	0.95 J	0.65 J	2.10
n-butylbenzene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
1,2-dibromo-3-chloropropane	2.00 U	2.00 U	2.00 U	2.00 U			2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
1,2,4-trichlorobenzene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
hexachlorobutadiene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
naphthalene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.10	1.00 U
1,2,3-trichlorobenzene	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Methyl tertiary butyl ether	1.00 U	1.00 U	1.00 U	1.00 U			1.00 U			1.00 U	1.00 U		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Acetone	5.00 U	5.00 U	5.00 U	5.00 U			1.37			5.00 U	5.00 U		5.00 U	5.00 U	5.49	5.00 U	5.00 U
carbon disulfide	2.00 U	2.00 U	2.00 U	2.00 U			2.00 U			2.00 U	2.00 U		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
2-butanone (MEK)	5.00 U	5.00 U	5.00 U	5.00 U			5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
tetrahydrofuran (THF)	5.00 U	5.00 U	5.00 U	5.00 U			5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
4-methyl-2-pentanone (MIBK)	5.00 U	5.00 U	5.00 U	5.00 U			5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-hexanone	5.00 U	5.00 U	5.00 U	5.00 U			5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2-chloroethyl vinyl ether	5.00 U	5.00 U	5.00 U	5.00 U			5.00 U			5.00 U	5.00 U		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U

Sample ID	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2	PMW-3-2
Sampling Date	7/18/2019	8/28/2019	10/24/2019	12/9/2019	1/14/2020	1/16/2020	1/20/2020	1/28/2020	2/4/2020	2/12/2020	2/26/2020	3/19/2020	4/16/2020	5/11/2020	7/14/2020	9/17/2020	12/21/2020
Days	-5	36	93	139	175	177	181	189	196	204	218	240	268	293	357	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.30																
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	281.75	18.27	1.96	80.38	2.85	1.62	3.30	15.88	1.07	0.95 U	5.32	24.38	0.66 J	0.95 U	3.88	0.74 J	315.64
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	0.86 J	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	0.62 J
Propane	2.68 U	2.68 U	89.83	4828.46	1.83 J	3.01	67.13	715.94	9.35	92.35	4.05	6.09	89.93	119.98	2694.11	2.86	0.78 J
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.161	0.03	3.60 D	5.80 D	0.23	0.18	0.17	10.20 D	1.05 D	5.40 D	1.80 D	3.20 D	4.80 D	7.20 D	0.57 D	14.00 D	0.30 D
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	18.47	21.56	17.01	15.43							17.98			16.51	20.42	20.27	17.13
Nitrite as N	0.20 U	0.20 U	0.20 U	0.20 U							0.20 U			0.20 U	0.20 U	0.20 U	0.06 J
Sulfate as SO4	20.97	309.26 D	262.59 D	64.77							68.03			56.84	74.06	61.04	22.10
Bromide	0.70	0.20 U	0.20 U	0.20 U							0.36			0.31	0.20 U	0.54	0.31
Nitrate as N	0.03 J	0.20 U	0.05 J	0.20 U							0.03 J			0.20 U	0.20 U	0.02 J	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U	0.20 U							0.20 U			0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS																	
pH (SU)	6.98	6.81	6.80	7.38	6.86	6.82	6.98	6.96	6.89	6.98	7.02	7.02	6.96	7.02	7.05	6.33	7
Temperature (°C)	24.74	22.6	23.19	20.40	21.10	21.60	13.80	17.9	18.5	17.8	18.3	22.7	21.7	24.3	20.6	21.22	19.4
Dissolved Oxygen (DO; mg/L)	0.33	0.15	0.1	0.52	0.09	0.04	0.11	0.51	0	0	0.1	0.04	0.06	0.1	0.01	6.98	0.15
Redox Potential (ORP; mV)	-105.0	-103.2	-76.0	-89.6	-78.1	-77.2	-64	-41.3	-50.1	-87.2	-57.6	-52.3	-60.1	-61.3	-78.9	-9.5	26.4
Specific Conductivity (mS/cm)	0.630	1.176	1.080	0.670	0.870	0.866	0.772	0.627	0.770	0.704	0.642	0.61	0.773	0.877	0.759	0.799	0.59
Depth to Water (ft-btoc) prior to purging	7.2	7.7	7.1	6.99	6.90	6.94	6.64	5.4	7.18	6.5	6.31	6.8	7.14	7.36	6.2	7.18	7.28
Purge Rate (mL/min)	300	240	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)																	
Propane Monooxygenase (PPO)																	
Ammonia Monooxygenase (AMO)																	
Soluble Methane Monooxygenase (SMMO)																	
Particulate methane monooxygenase (PMMO)																	
Ethene Monooxygenase (EtnC)																	
Epoxyalkane transferase (EtnE)																	

Notes:
U - The compound was not detected at the indicated PQL concentration.
J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.
D - Sample was diluted prior to analysis.
E - Estimated value, beyond linear range.
Blank - Not Analyzed.

Sample ID	PMW-3-3		PMW-3-3		PMW-3-3		PMW-3-3		PMW-3-3		PMW-3-3		PMW-3-3		PMW-3-3		PMW-3-3		PMW-3-3	
Sampling Date	7/18/2019		8/28/2019		10/24/2019		11/11/2019		12/9/2019		2/26/2020		5/11/2020		7/14/2020		9/17/2020		12/21/2020	
Days	-5		36		93		111		139		218		293		357		422		517	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
dichlorodifluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	17.20		13.49		12.22		11.72		20.41		0.68	J	1.00	U	1.00	U	1.00	U	42.49	
bromomethane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.77	
trichlorofluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
methylene chloride	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	57.32		52.69		51.82		61.25		47.52		5.29		1.00	U	1.00	U	1.26		47.69	
bromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	0.78	J	0.59	J	0.70	J	0.77	J	0.79	J	1.00	U	1.00	U	1.00	U	1.00	U	0.79	J
1,2-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chlorobenzene	4.12		2.85		2.90		3.37		3.33		1.00	U	1.00	U	1.00	U	1.00	U	2.75	
1,1,1,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-isopropyltoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,4-dichlorobenzene	0.19	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichlorobenzene	2.43		2.03		1.89		2.43		2.18		1.53		1.00	U	1.00	U	1.00	U	2.15	
n-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
hexachlorobutadiene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
naphthalene	1.00	U	1.09		1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.87	J	1.00	U
1,2,3-trichlorobenzene	1.00	U	0.68	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Acetone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-hexanone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	PMW-3-3	PMW-3-3	PMW-3-3	PMW-3-3	PMW-3-3	PMW-3-3	PMW-3-3	PMW-3-3	PMW-3-3	PMW-3-3
Sampling Date	7/18/2019	8/28/2019	10/24/2019	11/11/2019	12/9/2019	2/26/2020	5/11/2020	7/14/2020	9/17/2020	12/21/2020
Days	-5	36	93	111	139	218	293	357	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.18									
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	318.59	36.84	4.07	3.75	72.12	6.66	0.95 U	0.95 U	2.31	291.86
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	1.37 J	2.22 U	2.22 U	0.49 J	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	0.51 J
Propane	2.68 U	2.68 U	638.29	206.11	2571.04	19.06	27.61	23.15	33.28	0.62 J
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.175	0.03	13.40 D	0.50	3.20 D	7.60 D	4.80 D	2.40 D	1.40 D	0.90 D
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	18.18	17.72	15.76	15.51	14.54	16.46	16.23	17.81	16.73	14.94
Nitrite as N	0.20 U	0.20 U	0.20 U	0.08 J	0.20 U	0.20 U	0.24	0.20 U	1.25	0.20 U
Sulfate as SO4	19.52	483.35 D	377.53 D	282.37 D	118.10 D	96.85	119.65 D	137.14 D	90.51	23.76
Bromide	0.62	0.20 U	0.20 U	0.20 U	0.20 U	0.61	0.37	0.20 U	0.20 U	0.32
Nitrate as N	0.01 J	0.20 U	0.06 J	0.20 U	0.20 U	0.20 U	0.03 J	0.20 U	0.35	0.11 J
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS										
pH (SU)	6.98	6.66	6.69	6.78	7.34	7.12	6.94	7.03	6.69	7.01
Temperature (^{o}C)	25.31	21.9	23.31	21.91	19.40	18.20	24.30	22.2	20.98	18.01
Dissolved Oxygen (DO; mg/L)	0.45	0.18	0.1	0.39	0.00	0.11	0.03	0.01	5.72	0.23
Redox Potential (ORP; mV)	-94.9	-63.5	-49.0	-72.3	-71.8	-38.9	-53	-43.4	-61.7	46.6
Specific Conductivity (mS/cm)	0.631	1.547	1.352	1.169	0.750	0.653	1.054	0.937	0.893	0.600
Depth to Water (ft-btoc) prior to purging	7.3	7.85	7.11	6.97	7.96	6.35	7.41	6.24	7.21	7.33
Purge Rate (mL/min)	220	230	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)										
Propane Monooxygenase (PPO)										
Ammonia Monooxygenase (AMO)										
Soluble Methane Monooxygenase (SMMO)										
Particulate methane monooxygenase (PMMO)										
Ethene Monooxygenase (EtnC)										
Epoxyalkane transferase (EtnE)										

Notes:

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J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-3-4		PMW-3-4		PMW-3-4		PMW-3-4		PMW-3-4		PMW-3-4		PMW-3-4		PMW-3-4		PMW-3-4		PMW-3-4	
Sampling Date	7/18/2019		8/28/2019		10/23/2019		11/11/2019		12/9/2019		2/26/2020		5/12/2020		7/14/2020		9/17/2020		12/21/2020	
Days	-5		36		92		111		139		218		294		357		422		517	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
dichlorodifluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	15.08		19.14		11.46		9.89		12.85		2.85		1.00	U	1.00	U	1.00	U	32.39	
bromomethane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.85	J
trichlorofluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	0.15	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
methylene chloride	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	0.55	J	1.00	U	0.27	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	82.36		72.52		62.43		56.15		66.32		28.61		1.31		5.22		1.00	U	58.16	
bromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	0.73	J	0.80	J	0.55	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.63	J
1,2-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	1.00	U	1.00	U	0.17	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chlorobenzene	3.30		3.60		2.02		2.07		2.37		1.30		1.00	U	1.00	U	1.00	U	2.45	
1,1,1,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.06	J
4-isopropyltoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,4-dichlorobenzene	0.13	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichlorobenzene	1.77		2.03		1.32		1.39		1.76		1.90		0.78	J	1.00	U	1.20		1.71	
n-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.72		1.00	U
hexachlorobutadiene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
naphthalene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	7.62		1.00	U
1,2,3-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	2.68		1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Acetone	5.00	U	5.00	U	5.00	U	5.00	U	1.27	J	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-hexanone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	PMW-3-4	PMW-3-4	PMW-3-4	PMW-3-4	PMW-3-4	PMW-3-4	PMW-3-4	PMW-3-4	PMW-3-4	PMW-3-4
Sampling Date	7/18/2019	8/28/2019	10/23/2019	11/11/2019	12/9/2019	2/26/2020	5/12/2020	7/14/2020	9/17/2020	12/21/2020
Days	-5	36	92	111	139	218	294	357	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
1,4-Dioxane	1.82	1.58	1.19		1.22	1.56		0.98 J	0.68 J	3.82
REDUCED GASES	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
Methane	423.99	60.27	14.49	9.42	3.16	11.59	0.79 J	5.63	1.00	287.73
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	1.40 J	2.22 U	2.22 U	0.49 J	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U
Propane	2.68 U	2.68 U	378.41	508.27	445.02	332.22	88.72	174.40	31.74	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.161	0.06	0.07	0.02 U	0.01 J	0.08	0.06	0.03	0.07	0.32
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	14.26	15.36	15.97	15.83	16.86	0.20 U	15.07	15.69	15.96	18.41
Nitrite as N	0.20 U	0.20 U	0.10 J	0.09 J	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Sulfate as SO4	17.34	452.37 D	320.39 D	343.87 D	180.77 D	161.21 D	101.84 D	101.86 D	87.97	20.65
Bromide	0.71	0.20 U	0.20 U	0.20 U	0.20 U	0.50	0.44	0.56	0.20 U	0.30
Nitrate as N	0.02 J	0.20 U	0.07 J	0.01 J	0.20 U	0.20 U	0.01 J	0.20 U	0.01 J	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS										
pH (SU)	7.01	6.7	6.69	6.74	7.25	7.18	6.99	7.04	7.05	6.97
Temperature (^{o}C)	25.39	21.3	20.70	21.97	19.60	18.90	21.20	20.9	22.6	19.1
Dissolved Oxygen (DO; mg/L)	0.49	0.18	0.1	0.54	0.07	0.20	0.17	0.02	0	0.11
Redox Potential (ORP; mV)	-101.9	-88.2	-33.9	-83.0	-50.3	-41.4	-27.5	-57.4	-43.6	26.9
Specific Conductivity (mS/cm)	0.596	1.524	1.243	1.269	0.880	0.646	0.979	0.865	0.730	0.570
Depth to Water (ft-btoc) prior to purging	7.3	7.78	7.07	7.01	7.10	6.36	7.47	6.31	7.3	7.34
Purge Rate (mL/min)	200	280	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)										
Propane Monooxygenase (PPO)										
Ammonia Monooxygenase (AMO)										
Soluble Methane Monooxygenase (SMMO)										
Particulate methane monooxygenase (PMMO)										
Ethene Monooxygenase (EtnC)										
Epoxyalkane transferase (EtnE)										

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-1S		PMW-1S		PMW-1S		PMW-1S		PMW-1S		PMW-1S		PMW-1S		PMW-1S		PMW-1S	
Sampling Date	7/18/2019		8/28/2019		10/22/2019		12/9/2019		2/26/2020		5/12/2020		7/14/2020		9/17/2020		12/21/2020	
Days	-5		36		91		139		218		294		357		422		517	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
dichlorodifluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	3.35		2.61		4.13		2.29		1.00	U	1.76		1.31		0.66	J	10.72	
bromomethane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichlorofluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
methylene chloride	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	0.56	J	0.67	J	0.53	J	1.07		1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	59.88		56.39		62.69		85.57		47.20		32.77		25.13		16.70		47.04	
bromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	0.79	J	0.69	J	0.70	J	1.00		1.00	U	1.00	U	1.00	U	1.00	U	0.56	J
1,2-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	0.12	J	0.72	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.30	J
1,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chlorobenzene	2.84		2.49		2.49		3.12		2.08		1.34		1.01		1.00	U	1.86	
1,1,1,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U	0.02	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-isopropyltoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,4-dichlorobenzene	0.12	J	1.00	U	0.17	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichlorobenzene	1.84		1.54		1.37		2.39		2.16		1.87		1.41		1.12		1.76	
n-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
hexachlorobutadiene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
naphthalene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Acetone	5.00	U	5.00	U	5.00	U	2.94	J	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-hexanone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	PMW-1S	PMW-1S	PMW-1S	PMW-1S	PMW-1S	PMW-1S	PMW-1S	PMW-1S	PMW-1S
Sampling Date	7/18/2019	8/28/2019	10/22/2019	12/9/2019	2/26/2020	5/12/2020	7/14/2020	9/17/2020	12/21/2020
Days	-5	36	91	139	218	294	357	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.15								
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	233.05	89.05	55.63	72.30	66.69	49.81	158.03	14.66	193.38
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U
Propane	2.68 U	2.68 U	19.58	109.76	0.71 J	7.36	50.11	2.68 U	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.063	0.02 U	0.02 U	0.10	0.11	0.12	0.15	0.12	0.19
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	21.71	27.01	24.48	23.62	23.83	24.04	25.59	27.88	26.43
Nitrite as N	0.20 U	0.20 U	0.11 J	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.06 J
Sulfate as SO4	23.30	73.83	50.34	43.71	39.46	35.36	33.87	43.57	23.80
Bromide	0.73	0.20 U	0.20 U	0.20 U	0.24	0.28	0.25	0.20 U	0.20 U
Nitrate as N	0.03 J	0.20 U	0.01 J	0.20 U	0.02 J	0.03 J	0.20 U	0.06 J	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS									
pH (SU)	6.87	6.97	6.91	6.88	6.94	7.04	7.17	7.07	7.24
Temperature (^oC)	22.07	21.5	25.30	19.40	20.80	21.10	20.70	24.2	20.2
Dissolved Oxygen (DO; mg/L)	0.65	3.4	4.2	4.56	12.24	6.39	8.64	13.14	0
Redox Potential (ORP; mV)	-104.4	-43.2	16.5	17.4	179.2	74.4	34.3	-4.5	-166
Specific Conductivity (mS/cm)	0.657	0.814	0.714	0.690	0.655	0.829	0.678	0.730	0.552
Depth to Water (ft-btoc) prior to purging	7.7	8.2	7.34	7.51	6.74	7.91	6.69	7.81	7.69
Purge Rate (mL/min)	200	250	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)									
Propane Monooxygenase (PPO)									
Ammonia Monooxygenase (AMO)									
Soluble Methane Monooxygenase (SMMO)									
Particulate methane monooxygenase (PMMO)									
Ethene Monooxygenase (EtnC)									
Epoxyalkane transferase (EtnE)									

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-1I		PMW-1I		PMW-1I		PMW-1I		PMW-1I		PMW-1I		PMW-1I		PMW-1I		PMW-1I	
Sampling Date	7/18/2019		8/28/2019		10/22/2019		12/9/2019		2/26/2020		5/12/2020		7/14/2020		9/17/2020		12/21/2020	
Days	-5		36		91		139		218		294		357		422		517	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	μg/L		μg/L		μg/L		μg/L		μg/L		μg/L		μg/L		μg/L		μg/L	
dichlorodifluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	15.44		19.45		25.68		26.60		21.76		21.23		24.10		41.05		78.32	
bromomethane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichlorofluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	0.16	J	1.00	U	0.25	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
methylene chloride	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	68.19		80.66		81.92		67.82		56.78		42.57		53.61		62.32		74.46	
bromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	0.75	J	0.83	J	1.09		1.05		0.69	J	1.00	U	0.69	J	0.90	J	1.31	
1,2-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	1.00	U	1.00	U	0.05	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chlorobenzene	3.73		3.67		3.92		3.53		3.34		2.64		2.85		3.49		4.83	
1,1,1,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-isopropyltoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,4-dichlorobenzene	0.19	J	1.00	U	0.36	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichlorobenzene	2.48		2.43		2.55		2.83		2.86		2.58		2.22		2.63		4.18	
n-butylbenzene	1.00	U	1.00	U	0.26	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	1.00	U	0.63	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
hexachlorobutadiene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
naphthalene	1.00	U	1.00	U	1.00	U	1.07		1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichlorobenzene	1.00	U	1.00	U	0.95	J	0.84	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Acetone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-hexanone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	PMW-1I	PMW-1I	PMW-1I	PMW-1I	PMW-1I	PMW-1I	PMW-1I	PMW-1I	PMW-1I
Sampling Date	7/18/2019	8/28/2019	10/22/2019	12/9/2019	2/26/2020	5/12/2020	7/14/2020	9/17/2020	12/21/2020
Days	-5	36	91	139	218	294	357	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.56								
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	360.86	222.89	129.38	288.77	774.93	200.81	588.65	196.83	348.00
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	1.23 J	0.76 J	0.63 J	1.85 J	2.22 U	2.22 U	1.44 J	2.22 U	2.46
Propane	2.68 U	2.68 U	2.68 U	0.99 J	2.68 U	2.68 U	2.68 U	2.68 U	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.161	0.14	0.02	0.22	0.20	0.21	0.24	0.26	0.26
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	16.61	14.32	14.53	14.53	17.29	16.58	16.74	15.32	15.67
Nitrite as N	0.20 U	0.20 U	0.07 J	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Sulfate as SO4	18.75	18.51	18.85	17.63	19.06 D	18.94	18.41	17.82	18.33
Bromide	0.72	0.20 U	0.20 J	0.20 U	0.20	0.23	0.26	0.28	0.34
Nitrate as N	0.03 J	0.20 U	0.20 U	0.20 U	0.01 J	0.20 U	0.20 U	0.20 U	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS									
pH (SU)	6.92	7.1	6.89	6.91	6.95	7.01	7.14	7.05	7.2
Temperature (^{o}C)	22.59	21.2	27.33	19.30	20.90	21.50	20.30	23.7	19.5
Dissolved Oxygen (DO; mg/L)	0.56	0.15	0.1	0.04	0.20	0.14	0.06	0.05	0
Redox Potential (ORP; mV)	-90.9	-107	-93.0	-101.9	-56.3	-63.5	-97.4	-110.4	-164.8
Specific Conductivity (mS/cm)	0.648	0.631	0.632	0.606	0.623	0.763	0.626	0.665	0.544
Depth to Water (ft-btoc) prior to purging	7.6	8.1	7.3	7.42	6.64	7.81	6.6	7.74	7.62
Purge Rate (mL/min)	200	250	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)									
Propane Monooxygenase (PPO)									
Ammonia Monooxygenase (AMO)									
Soluble Methane Monooxygenase (SMMO)									
Particulate methane monooxygenase (PMMO)									
Ethene Monooxygenase (EtnC)									
Epoxyalkane transferase (EtnE)									

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-1D		PMW-1D		PMW-1D		PMW-1D		PMW-1D		PMW-1D		PMW-1D		PMW-1D		PMW-1D	
Sampling Date	7/18/2019		8/29/2019		10/22/2019		12/9/2019		2/26/2020		5/12/2020		7/14/2020		9/17/2020		12/21/2020	
Days	-5		37		91		139		218		294		357		422		517	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
dichlorodifluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	4.04		3.95		9.60		6.14		8.06		8.68		6.88		13.51		26.07	
bromomethane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichlorofluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	1.00	U	0.54	J	0.29	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
methylene chloride	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	1.80		2.19		0.99	J	1.57		1.21		1.00	U	0.88	J	0.80	J	1.00	U
1,1-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	95.88		99.86		87.79		105.31		97.37		84.16		71.30		81.39		71.47	
bromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	0.66	J	0.71	J	0.62	J	0.84	J	0.73	J	0.69	J	1.00	U	0.62	J	0.66	J
1,2-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	1.00	U	0.68	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chlorobenzene	2.55		2.66		2.11		2.64		2.81		2.59		2.42		2.49		2.75	
1,1,1,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-isopropyltoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,4-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichlorobenzene	1.62		1.74		1.30		1.44		1.70		1.86		1.49		1.40		1.00	U
n-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	0.55	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
hexachlorobutadiene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
naphthalene	1.00	U	1.35		1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichlorobenzene	1.00	U	0.79	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Acetone	5.00	U	5.00	U	5.00	U	5.00	J	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-hexanone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	PMW-1D	PMW-1D	PMW-1D	PMW-1D	PMW-1D	PMW-1D	PMW-1D	PMW-1D	PMW-1D
Sampling Date	7/18/2019	8/29/2019	10/22/2019	12/9/2019	2/26/2020	5/12/2020	7/14/2020	9/17/2020	12/21/2020
Days	-5	37	91	139	218	294	357	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.73	1.53	1.09	1.61	2.10		1.75	1.89	2.76
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	417.72	155.88	128.30	213.27	1386.38	231.65	1209.64	181.57	317.43
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	0.61 J	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	0.55 J	2.22 U	1.09 J
Propane	2.68 U	2.68 U	2.68 U	2.68 U	2.68 U	2.68 U	2.68 U	2.68 U	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.217	0.07	0.02 U	0.16	0.26	0.20	0.22	0.26	0.25
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	13.33	14.40	17.97	14.16	14.36	14.45	14.79	15.01	17.44
Nitrite as N	0.20 U	0.20 U	0.08 J	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Sulfate as SO4	16.03	16.15	18.46	16.75	16.96	17.07	17.28	16.26	17.99
Bromide	0.70	0.20 U	0.21	0.20 U	0.16 J	0.23	0.25	0.23	0.31
Nitrate as N	0.03 J	0.20 U	0.20 U	0.20 U	0.20 U	0.01 J	0.20 U	0.20 U	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS									
pH (SU)	6.93	7.05	6.87	6.95	6.93	6.98	7.22	7.13	7.21
Temperature (^{o}C)	23.34	20.3	25.33	18.90	18.20	22.20	20.40	24.2	19.4
Dissolved Oxygen (DO; mg/L)	0.51	0.18	0.1	0.05	0.15	0.11	0.01	0.06	0
Redox Potential (ORP; mV)	-91.7	-130.9	-88.1	-112.5	-100.4	-85.5	-108.1	-118.9	-139.5
Specific Conductivity (mS/cm)	0.641	0.632	0.642	0.622	0.624	0.761	0.615	0.662	0.537
Depth to Water (ft-btoc) prior to purging	7.5	7.65	7.1	7.25	6.48	7.64	6.4	7.54	7.41
Purge Rate (mL/min)	200	290	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)									
Propane Monooxygenase (PPO)									
Ammonia Monooxygenase (AMO)									
Soluble Methane Monooxygenase (SMMO)									
Particulate methane monooxygenase (PMMO)									
Ethene Monooxygenase (EtnC)									
Epoxyalkane transferase (EtnE)									

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-2I		PMW-2I		PMW-2I		PMW-2I		PMW-2I		PMW-2I		PMW-2I		PMW-2I		PMW-2I	
Sampling Date	7/18/2019		8/28/2019		10/22/2019		12/9/2019		2/27/2020		5/13/2020		7/13/2020		9/17/2020		12/21/2020	
Days	-5		36		91		139		219		295		356		422		517	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
dichlorodifluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	16.95		20.94		16.04		4.96		5.09		4.70		6.76		1.00	U	32.79	
bromomethane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichlorofluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
methylene chloride	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	22.32		37.86		21.33		34.57		9.03		6.25		11.32		9.65		32.53	
bromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	0.63	J	0.79	J	1.00	U	0.70	J	1.00	U	1.00	U	1.00	U	1.00	U	0.47	J
1,2-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chlorobenzene	1.64		2.69		1.30		1.87		1.15		0.68	J	0.89	J	1.00	U	1.48	
1,1,1,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-isopropyltoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,4-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichlorobenzene	1.03		1.25		0.71	J	0.85	J	1.10		0.93	J	1.36		1.00	U	1.46	
n-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
hexachlorobutadiene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
naphthalene	1.00	U	1.00	U	1.00	U	1.00	U	1.56		1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.10		1.00	U	1.00	U	1.00	U	1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Acetone	5.00	U	5.00	U	5.00	U	2.95	J	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-hexanone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	PMW-2I	PMW-2I	PMW-2I	PMW-2I	PMW-2I	PMW-2I	PMW-2I	PMW-2I	PMW-2I
Sampling Date	7/18/2019	8/28/2019	10/22/2019	12/9/2019	2/27/2020	5/13/2020	7/13/2020	9/17/2020	12/21/2020
Days	-5	36	91	139	219	295	356	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	0.97								
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	188.66	63.41	65.74	45.69	177.01	52.45	295.45	1.18	144.61
Ethane	0.44 J	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	4.38	0.97 J	1.13 J	2.22 U	2.22 U	2.22 U	1.22 J	2.22 U	1.75 J
Propane	0.94 J	2.68 U	7.88	2824.32	11.38	2.68 U	3.09	5.14	2.68 U
Acetylene	3.43 J	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.105	0.09	0.02 U	0.08	0.12	0.15	0.15	0.48	0.19
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	19.05	18.03	21.24	20.00	22.07	22.17	24.27	21.28	23.56
Nitrite as N	0.20 U	0.20 U	0.13 J	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.08 J
Sulfate as SO4	24.47	47.89	34.32	85.69	35.22	31.85	31.36	90.80	25.14
Bromide	0.78	0.20 U	0.20 U	0.20 U	0.24	0.26	0.16 J	0.20 U	0.33
Nitrate as N	0.03 J	0.20 U	0.01 J	0.20 U	0.02 J	0.20 U	0.20 U	0.06 J	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS									
pH (SU)	6.87	7.08	6.86	6.93	6.94	7.05	7.13	7.04	7.25
Temperature (^{o}C)	22.43	21.5	24.82	19.10	16.30	21.30	21.20	22.3	20
Dissolved Oxygen (DO; mg/L)	0.55	0.16	0.1	0.11	0.55	0.14	1.08	4.66	0
Redox Potential (ORP; mV)	-84.0	-77.2	-21.1	-32.9	21.3	-24.7	9	38.2	-162.7
Specific Conductivity (mS/cm)	0.653	0.698	0.667	0.785	0.696	0.804	0.684	0.720	0.569
Depth to Water (ft-btoc) prior to purging	7.6	8.05	7.31	7.40	6.67	7.81	6.88	7.75	7.61
Purge Rate (mL/min)	200	230	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)									
Propane Monooxygenase (PPO)									
Ammonia Monooxygenase (AMO)									
Soluble Methane Monooxygenase (SMMO)									
Particulate methane monooxygenase (PMMO)									
Ethene Monooxygenase (EtnC)									
Epoxyalkane transferase (EtnE)									

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-2D		PMW-2D		PMW-2D		PMW-2D		PMW-2D		PMW-2D		PMW-2D		PMW-2D		PMW-2D	
Sampling Date	7/18/2019		8/28/2019		10/22/2019		12/9/2019		2/27/2020		5/13/2020		7/13/2020		9/17/2020		12/21/2020	
Days	-5		36		91		139		219		295		356		422		517	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
dichlorodifluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	12.59		15.99		7.46		12.56		5.39		1.00	U	1.00	U	1.00	U	39.29	
bromomethane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.44	
trichlorofluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
methylene chloride	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	1.00	U	1.00	U	0.57	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	21.54		53.35		38.75		53.57		34.02		4.55		4.68		1.69		65.83	
bromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	1.00	U	0.74	J	0.66	J	0.95	J	1.00	U	1.00	U	1.00	U	1.00	U	0.79	J
1,2-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chlorobenzene	1.97		2.49		2.27		2.33		2.19		1.00	U	1.00	U	1.00	U	2.82	
1,1,1,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-isopropyltoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,4-dichlorobenzene	1.00	U	1.00	U	0.11	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichlorobenzene	1.27		1.74		1.35		1.58		1.79		0.87	J	1.00	U	1.00	U	2.18	
n-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
hexachlorobutadiene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
naphthalene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Acetone	5.00	U	9.20		5.00	U	4.55	J	5.00	U	2.56		7.66		5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-hexanone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	PMW-2D	PMW-2D	PMW-2D	PMW-2D	PMW-2D	PMW-2D	PMW-2D	PMW-2D	PMW-2D
Sampling Date	7/18/2019	8/28/2019	10/22/2019	12/9/2019	2/27/2020	5/13/2020	7/13/2020	9/17/2020	12/21/2020
Days	-5	36	91	139	219	295	356	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
1,4-Dioxane	1.53								
REDUCED GASES	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
Methane	261.12	24.11	4.79	0.95 U	11.94	0.95 U	2.44	1.96	272.25
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	6.28	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	0.92 J
Propane	2.68 U	2.68 U	425.29	343.19	518.96	170.28	1253.67	249.73	0.68 J
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.14	0.02 U	0.02 U	0.06	0.05	0.04	0.03	0.05	0.26
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	16.11	15.85	17.45	16.67	18.36	18.26	17.36	16.83	17.80
Nitrite as N	0.20 U	0.20 U	0.11 J	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.09 J
Sulfate as SO4	22.73	513.83 D	367.51 D	136.95 D	130.24 D	162.78 D	150.12 D	118.70 D	24.04
Bromide	0.76	0.20 U	0.20 U	0.20 U	0.43	0.78	0.20 U	0.20 U	0.35
Nitrate as N	0.03 J	0.20 U	0.11 J	0.20 U	0.20 U	0.20 U	0.20 U	0.02 J	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS									
pH (SU)	6.89	6.63	6.58	6.83	6.90	6.92	6.92	6.93	7.27
Temperature (^{o}C)	23.42	22.4	24.55	17.40	15.70	20.40	21.70	22.4	20
Dissolved Oxygen (DO; mg/L)	0.62	7.01	7.0	3.76	4.04	7.37	18.04	14.36	0
Redox Potential (ORP; mV)	-93.2	16.7	34.7	54.5	73.9	59.8	86.1	124.3	-167.1
Specific Conductivity (mS/cm)	0.652	1.559	1.302	0.864	0.794	1.097	0.935	0.770	0.563
Depth to Water (ft-btoc) prior to purging	7.8	8.18	7.4	7.48	6.77	7.91	6.98	0.79	7.71
Purge Rate (mL/min)	200	250	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)									
Propane Monooxygenase (PPO)									
Ammonia Monooxygenase (AMO)									
Soluble Methane Monooxygenase (SMMO)									
Particulate methane monooxygenase (PMMO)									
Ethene Monooxygenase (EtnC)									
Epoxyalkane transferase (EtnE)									

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-3I		PMW-3I		PMW-3I		PMW-3I		PMW-3I		PMW-3I		PMW-3I		PMW-3I		PMW-3I	
Sampling Date	7/18/2019		8/29/2019		10/22/2019		12/9/2019		2/27/2020		5/13/2020		7/13/2020		9/17/2020		12/21/2020	
Days	-5		37		91		139		219		295		356		422		517	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	μg/L		μg/L		μg/L		μg/L		μg/L		μg/L		μg/L		μg/L		μg/L	
dichlorodifluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromomethane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichlorofluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
methylene chloride	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	10.61		13.70		13.01		20.84		0.77	J	1.00	U	1.00	U	1.00	U	11.64	
bromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	1.00	U	1.00	U	0.27	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-isopropyltoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,4-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
hexachlorobutadiene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
naphthalene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Acetone	5.00	U	5.00	U	5.00	U	1.43	J	5.00	U	5.00	U	6.54		5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-hexanone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	PMW-3I	PMW-3I	PMW-3I	PMW-3I	PMW-3I	PMW-3I	PMW-3I	PMW-3I	PMW-3I
Sampling Date	7/18/2019	8/29/2019	10/22/2019	12/9/2019	2/27/2020	5/13/2020	7/13/2020	9/17/2020	12/21/2020
Days	-5	37	91	139	219	295	356	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
1,4-Dioxane	0.64								
REDUCED GASES	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
Methane	104.08	16.65	3.41	161.12	7.13	1.95	4.58	1.40	77.20
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U
Propane	2.68 U	2.68 U	114.58	2.68 U	2.68 U	2.68 U	261.57	0.73 J	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.084	0.02 U	0.02 U	0.06	0.17	0.02	0.01 J	0.05	0.17
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	31.46	35.23	40.38	35.66	35.67	28.00	27.53	34.68	31.49
Nitrite as N	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Sulfate as SO4	19.31	190.66 D	109.43 D	141.81 D	46.44	40.47	35.46	83.10	20.59
Bromide	0.20 U	0.20 U	0.20 U	0.20 U	0.17 J	0.26	0.28	0.20 U	0.20 U
Nitrate as N	0.03 J	0.20 U	0.01 J	0.20 U	0.20 U	0.20 U	0.20 U	0.06 J	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS									
pH (SU)	7.00	6.98	6.81	6.83	6.89	7.06	7.08	7.09	7.34
Temperature (°C)	24.80	25.11	23.60	18.30	16.40	18.60	25.50	22.7	19.6
Dissolved Oxygen (DO; mg/L)	0.50	5.67	13.6	6.59	6.85	13.56	23.91	37.40	0
Redox Potential (ORP; mV)	-97.3	40.5	144.7	70.4	89.3	166.5	157.1	187.2	-151.6
Specific Conductivity (mS/cm)	0.638	0.866	0.867	0.930	0.727	0.815	0.843	0.720	0.542
Depth to Water (ft-btoc) prior to purging	6.7	6.84	6.34	6.50	5.71	6.87	9.57	0.676	0.669
Purge Rate (mL/min)	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)									
Propane Monooxygenase (PPO)									
Ammonia Monooxygenase (AMO)									
Soluble Methane Monooxygenase (SMMO)									
Particulate methane monooxygenase (PMMO)									
Ethene Monooxygenase (EtnC)									
Epoxyalkane transferase (EtnE)									

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-3D		PMW-3D		PMW-3D		PMW-3D		PMW-3D		PMW-3D		PMW-3D		PMW-3D		PMW-3D	
Sampling Date	7/18/2019		8/29/2019		10/22/2019		12/9/2019		2/27/2020		5/13/2020		7/13/2020		9/17/2020		12/21/2020	
Days	-5		37		91		139		219		295		356		422		517	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
dichlorodifluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	0.67	J	1.00	U	0.44	J	0.92	J	1.00	U	0.83	J	1.20		1.00	U	1.23	
bromomethane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichlorofluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
methylene chloride	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	1.28		1.13		0.81	J	1.18		0.95	J	1.00	U	1.13		1.00	U	0.76	J
1,1-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	59.61		43.83		35.76		49.49		44.72		39.20		54.47		78.19		31.30	
bromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	0.16	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	0.74	J	0.82	J	0.67	J	0.92	J	0.79	J	1.00	U	1.00	U	1.00	U	0.55	J
1,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chlorobenzene	0.61	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.36	J
1,1,1,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-isopropyltoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,4-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichlorobenzene	0.37	J	0.57	J	0.25	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.41	J
n-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
hexachlorobutadiene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
naphthalene	1.00	U	1.00	U	1.00	U	1.30		1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichlorobenzene	1.00	U	1.00	U	1.00	U	0.92	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Acetone	5.00	U	5.00	U	5.00	U	1.67	J	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-hexanone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	PMW-3D	PMW-3D	PMW-3D	PMW-3D	PMW-3D	PMW-3D	PMW-3D	PMW-3D	PMW-3D
Sampling Date	7/18/2019	8/29/2019	10/22/2019	12/9/2019	2/27/2020	5/13/2020	7/13/2020	9/17/2020	12/21/2020
Days	-5	37	91	139	219	295	356	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
1,4-Dioxane	1.41								
REDUCED GASES	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
Methane	345.85	91.87	67.51	236.25	558.71	109.49	700.15	253.34	133.31
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U
Propane	2.68 U	2.68 U	2.68 U	2.68 U	2.68 U	2.68 U	2.68 U	4.11	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.077	0.09	0.02 U	0.13	0.12	0.11	0.11	0.13	0.14
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	16.73	26.74	32.35	22.52	25.10	18.30	12.78	12.70	31.34
Nitrite as N	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Sulfate as SO4	18.29	22.69	20.85	19.35	20.52	21.93	18.37	18.94	20.37
Bromide	0.20 U	0.20 U	0.20 U	0.20 U	0.18 J	0.21	0.19 J	0.19 J	0.20 U
Nitrate as N	0.02 J	0.20 U	0.01 J	0.20 U	0.01 J	0.01 J	0.20 U	0.02 J	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS									
pH (SU)	7.01	7.16	6.93	7.02	7.05	7.07	7.07	7.19	7.28
Temperature (^{o}C)	25.94	24.75	23.17	17.90	15.70	19.00	25.50	23	19.5
Dissolved Oxygen (DO; mg/L)	0.50	0.07	0.1	0.21	0.30	0.15	0.07	0.00	0
Redox Potential (ORP; mV)	-113.5	-141.6	-94.8	-77.9	-63.0	-65.6	-64.1	-93.1	-171.4
Specific Conductivity (mS/cm)	0.658	0.590	0.713	0.656	0.651	0.766	0.785	0.530	0.555
Depth to Water (ft-btoc) prior to purging	6.7	6.94	6.34	6.54	5.76	6.91	6	6.74	6.72
Purge Rate (mL/min)	200	260	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)									
Propane Monooxygenase (PPO)									
Ammonia Monooxygenase (AMO)									
Soluble Methane Monooxygenase (SMMO)									
Particulate methane monooxygenase (PMMO)									
Ethene Monooxygenase (EtnC)									
Epoxyalkane transferase (EtnE)									

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	PMW-4D		PMW-4D		PMW-4D		PMW-4D		PMW-4D		PMW-4D		PMW-4D		PMW-4D		PMW-4D	
Sampling Date	7/18/2019		8/29/2019		10/22/2019		12/8/2019		2/27/2020		5/12/2020		7/13/2020		9/17/2020		12/21/2020	
Days	-5		37		91		138		219		294		356		422		517	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	μg/L		μg/L		μg/L		μg/L		μg/L		μg/L		μg/L		μg/L		μg/L	
dichlorodifluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	0.75	J	1.00	U	0.52	J	1.01		0.78	J	1.16		1.32		3.36		4.85	
bromomethane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichlorofluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	0.17	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
methylene chloride	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	1.33		1.18		0.94	J	1.37		1.02		1.00	U	0.90	J	1.51		1.31	
1,1-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	68.89		56.90		39.85		55.68		43.66		41.36		45.88		89.89		51.55	
bromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	0.15	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	0.69	J	0.82	J	0.67	J	0.90	J	0.91	J	1.00	U	1.00	U	0.81	J	0.72	J
1,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chlorobenzene	0.60	J	0.52	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.77	J	0.51	J
1,1,1,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-isopropyltoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,4-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichlorobenzene	0.44	J	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.53	J	0.52	J
n-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
hexachlorobutadiene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
naphthalene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.83	J	1.00	U
1,2,3-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Acetone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-hexanone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	0.55	J	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	PMW-4D	PMW-4D	PMW-4D	PMW-4D	PMW-4D	PMW-4D	PMW-4D	PMW-4D	PMW-4D
Sampling Date	7/18/2019	8/29/2019	10/22/2019	12/8/2019	2/27/2020	5/12/2020	7/13/2020	9/17/2020	12/21/2020
Days	-5	37	91	138	219	294	356	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.89	1.13	0.55 J	1.46	2.53		2.50	1.82	2.74
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	371.29	82.04	76.27	301.80	437.46	153.90	462.24	132.12	156.60
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U
Propane	2.68 U	2.68 U	23.06	2.68 U	58.43	34.98	99.65	39.60	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.077	0.07	0.02 U	0.12	0.12	0.11	0.09	0.10	0.14
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	13.67	20.81	30.42	22.96	23.78	21.25	13.82	12.49	24.65
Nitrite as N	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Sulfate as SO4	17.67	131.02 D	24.92	24.45	25.00	23.50	23.95	74.27	19.44
Bromide	0.64	0.20 U	0.20 U	0.20 U	0.19 J	0.22	0.21	0.20 U	0.20 U
Nitrate as N	0.02 J	0.20 U	0.01 J	0.20 U	0.01 J	0.20 U	0.20 U	0.04 J	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS									
pH (SU)	6.99	7.11	6.88	7.02	7.00	6.96	6.99	7.09	7.04
Temperature (^{o}C)	24.70	24.34	23.07	16.30	15.70	21.60	27.90	22.5	19.4
Dissolved Oxygen (DO; mg/L)	0.52	0.04	0.1	0.51	0.55	0.44	0.06	0.08	0.16
Redox Potential (ORP; mV)	-121.2	-242.9	-86.9	-66.4	-58.0	-65.0	-59.1	-74.2	-28.3
Specific Conductivity (mS/cm)	0.643	0.790	0.715	0.670	0.668	0.784	0.802	0.640	0.553
Depth to Water (ft-btoc) prior to purging	6.6	6.72	6.24	6.44	5.64	6.74	5.84	6.71	6.66
Purge Rate (mL/min)	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)									
Propane Monooxygenase (PPO)									
Ammonia Monooxygenase (AMO)									
Soluble Methane Monooxygenase (SMMO)									
Particulate methane monooxygenase (PMMO)									
Ethene Monooxygenase (EtnC)									
Epoxyalkane transferase (EtnE)									

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	BMW-1I		BMW-1I		BMW-1I		BMW-1I		BMW-1I		BMW-1I		BMW-1I		BMW-1I		BMW-1I		BMW-1I		BMW-1I		BMW-1I	
Sampling Date	7/17/2019		8/29/2019		10/2/2019		10/9/2019		10/16/2019		10/22/2019		12/8/2019		2/27/2020		5/12/2020		7/13/2020		9/17/2020		12/21/2020	
Days	-6		37		71		78		85		91		138		219		294		356		422		517	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
dichlorodifluoromethane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	0.02	J							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	5.97		8.46								10.34		12.56		13.88		16.42		12.87		20.55		38.32	
bromomethane	2.00	U	0.04	J							2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichlorofluoromethane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	1.00	U	0.29	J							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
methylene chloride	2.00	U	2.00	U							2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	0.64	J	0.77	J							0.66	J	0.78	J	0.84	J	1.00	U	1.00	U	0.52	J	1.00	U
1,1-dichloroethane	1.00	U	0.07	J							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	94.67		85.51								92.14		89.68		110.74		82.11		66.32		69.88		63.89	
bromochloromethane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	0.73	J	0.68	J							0.75	J	0.81	J	1.13		0.77	J	0.69	J	0.78	J	0.88	J
1,2-dichloroethane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloropropane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chlorobenzene	3.25		3.00								2.92		2.73		4.42		3.44		2.48		2.61		3.34	
1,1,1,2-tetrachloroethane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	0.03	J							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U							2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U							2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	0.05	J							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-isopropyltoluene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,4-dichlorobenzene	1.00	U	0.22	J							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichlorobenzene	2.24		1.99								1.78		1.70		3.46		2.71		1.64		1.35		2.43	
n-butylbenzene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U							2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
hexachlorobutadiene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
naphthalene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichlorobenzene	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.61	J	1.00	U
Acetone	0.39	J	0.38	J							5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U							2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	0.11	J							5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U							5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U							5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-hexanone	5.00	U	0.08	J							5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U							5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	BMW-1I	BMW-1I	BMW-1I	BMW-1I	BMW-1I	BMW-1I	BMW-1I	BMW-1I	BMW-1I	BMW-1I	BMW-1I	BMW-1I
Sampling Date	7/17/2019	8/29/2019	10/2/2019	10/9/2019	10/16/2019	10/22/2019	12/8/2019	2/27/2020	5/12/2020	7/13/2020	9/17/2020	12/21/2020
Days	-6	37	71	78	85	91	138	219	294	356	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
1,4-Dioxane	1.61											
REDUCED GASES	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
Methane	421.25	148.81	146.73	175.89	348.72	146.87	281.80	1204.29	291.32	785.35	179.51	294.83
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	0.48 J	2.22 U	2.22 U	2.22 U	0.61 J	2.22 U	2.22 U	0.49 J	2.22 U	0.66 J	2.22 U	1.64 J
Propane	2.68 U	2.68 U	2.68 U	2.68 U	1.56 J	0.67 J	2.68 U	1.05 J	2.68 U	2.68 U	2.68 U	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.203	0.13	0.10	0.14	0.06	0.02 U	0.25	0.24	0.24	0.24	0.28	0.30
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	14.56	14.59		12.78	14.42	14.39	13.14	14.70	14.78	15.22	14.37	15.77
Nitrite as N	0.20 U	0.20 U		0.20 U	0.20 U	0.05 J	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Sulfate as SO4	17.22	17.70		17.22	17.56	17.45	15.90 D	16.68	17.12	17.43	16.02	17.18
Bromide	0.71	0.20 U		0.20 U	0.21	0.24	0.20 U	0.21	0.24	0.24	0.22	0.30
Nitrate as N	0.02 J	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U	0.01 J	0.20 U	0.20 U	0.20 U	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS												
pH (SU)	6.99	7.11	7.02	7.03	7.00	6.95	6.96	6.96	7.01	6.97	7.16	7.23
Temperature (^{o}C)	23.71	21.1	24.42	20.29	21.25	25.47	13.30	16.1	22.7	27.4	25.2	19.4
Dissolved Oxygen (DO; mg/L)	0.65	0.1	0.1	0.14	0.11	0.11	0.48	0.51	0.1	0.09	0.14	0
Redox Potential (ORP; mV)	-99.9	-134.2	-131.4	-109.3	-88.9	66.7	-80.4	-62.4	-87.6	-86	-118.9	-187.9
Specific Conductivity (mS/cm)	0.624	0.631	0.594	0.522	0.520	0.629	0.597	0.582	0.757	0.786	0.669	0.529
Depth to Water (ft-btoc) prior to purging	7.4	7.64	7.53	7.71	7.62	7.04	7.31	6.4	7.57	6.7	7.54	7.41
Purge Rate (mL/min)	200	300	200	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)												
Propane Monooxygenase (PPO)												
Ammonia Monooxygenase (AMO)												
Soluble Methane Monooxygenase (SMMO)												
Particulate methane monooxygenase (PMMO)												
Ethene Monooxygenase (EtnC)												
Epoxyalkane transferase (EtnE)												

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

Sample ID	BMW-1D		BMW-1D		BMW-1D		BMW-1D		BMW-1D		BMW-1D		BMW-1D		BMW-1D		BMW-1D		BMW-1D		BMW-1D		BMW-1D		BMW-1D		BMW-1D		BMW-1D	
Sampling Date	7/17/2019		8/29/2019		9/10/2019		10/2/2019		10/9/2019		10/16/2019		10/22/2019		11/11/2019		12/8/2019		2/27/2020		4/16/2020		5/12/2020		7/13/2020		9/16/2020		12/21/2020	
Days	-6		37		49		71		78		85		91		111		138		219		268		294		356		421		517	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
dichlorodifluoromethane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	1.81		1.00	U	1.82								1.55		1.53		2.75		2.08		3.3		2.78		2.17		2.77		5.46	
bromomethane	2.00	U	2.00	U	2.00	U							2.00	U	2.00	U	2.00	U	2.00	U	2.0	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
trichlorofluoromethane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	0.18	J	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
methylene chloride	2.00	U	2.00	U	2.00	U							2.00	U	2.00	U	2.00	U	2.00	U	2.0	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	2.09		2.25		1.91								1.46		1.77		2.55		2.18		2.9		2.03		1.74		2.59		1.88	
1,1-dichloroethane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	92.06		101.22	E	91.72								76.32		84.56		124.62		98.41		140.3		105.53		78.13		77.92		93.76	
bromochloromethane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	0.39	J	1.00	U	1.00	U							0.32	J	1.00	U	1.00	U	1.00	U	0.8	J	1.00	U	1.00	U	1.00	U	0.56	J
1,2-dichloroethane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	0.30	J	1.00	U	1.00	U							0.35	J	1.00	U	0.74	J	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	0.44	J
1,2-dichloropropane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
chlorobenzene	1.50		1.44		1.34								0.89	J	0.92	J	1.38		1.59		2.4		1.87		1.45		1.38		1.94	
1,1,1,2-tetrachloroethane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U	2.00	U							2.00	U	2.00	U	2.00	U	2.00	U	2.0	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U	2.00	U							2.00	U	2.00	U	2.00	U	2.00	U	2.0	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
4-isopropyltoluene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
1,4-dichlorobenzene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichlorobenzene	0.92	J	1.01		1.13								0.59	J	0.70	J	0.98	J	1.12		1.6		1.14		0.75	J	0.58	J	1.23	
n-butylbenzene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U	2.00	U							2.00	U	2.00	U	2.00	U	2.00	U	2.0	U	2.00	U	2.00	U	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
hexachlorobutadiene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
naphthalene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichlorobenzene	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U	1.00	U							1.00	U	1.00	U	1.00	U	1.00	U	1.0	U	1.00	U	1.00	U	1.00	U	1.00	U
Acetone	5.00	U	5.00	U	1.21								5.00	U	5.00	U	5.00	U	5.00	U	5.0	U	1.32		5.00	U	5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U	2.00	U							2.00	U	2.00	U	2.00	U	2.00	U	2.0	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	5.00	U	5.00	U							5.00	U	5.00	U	5.00	U	5.00	U	5.0	U	5.00	U	5.00	U	5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U	5.00	U							5.00	U	5.00	U	5.00	U	5.00	U	5.0	U	5.00	U	5.00	U	5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U	5.00	U							5.00	U	5.00	U	5.00	U	5.00	U	5.0	U	5.00	U	5.00	U	5.00	U	5.00	U
2-hexanone	5.00	U	5.00	U	5.00	U							5.00	U	5.00	U	5.00	U	5.00	U	5.0	U	5.00	U	5.00	U	5.00	U	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U	5.00	U							5.00	U	5.00	U	5.00	U	5.00	U	5.0	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	BMW-1D	BMW-1D	BMW-1D	BMW-1D	BMW-1D	BMW-1D	BMW-1D	BMW-1D	BMW-1D	BMW-1D	BMW-1D	BMW-1D	BMW-1D	BMW-1D	BMW-1D
Sampling Date	7/17/2019	8/29/2019	9/10/2019	10/2/2019	10/9/2019	10/16/2019	10/22/2019	11/11/2019	12/8/2019	2/27/2020	4/16/2020	5/12/2020	7/13/2020	9/16/2020	12/21/2020
Days	-6	37	49	71	78	85	91	111	138	219	268	294	356	421	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.88	1.78	1.26				1.91		1.90	3.69			2.02	1.41	2.44
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	424.78	128.02		111.44	120.98	233.54	133.50	254.02	315.31	1399.27	240.29	331.84	710.95	144.21	238.30
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	0.44 J	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U	2.22 U
Propane	2.68 U	2.68 U	2.68 U	2.68 U	2.68 U	2.20 J	2.27 J	2.68 U	2.68 U	2.68 U	2.68 U	2.68 U	2.68 U	2.68 U	2.68 U
Acetylene	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.105	0.04		0.04	0.09	0.07	0.11	0.12	0.14	0.16	0.19	0.14	0.15	0.16	0.17
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	14.37	15.55	17.10		18.23	20.62	21.40	22.44	14.95	16.93		15.93	16.06	18.55	20.12
Nitrite as N	0.20 U	0.20 U	0.20 U		0.20 U	0.12 J	0.09 J	0.20 U	0.20 U	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U
Sulfate as SO4	17.13	18.17	17.68		18.58	18.77	19.57	19.19	16.99	18.37 D		17.95	17.91	18.54	19.39
Bromide	0.68	0.20 U	0.20 U		0.20 U	0.23	0.20 U	0.19 J	0.20 U	0.25		0.26	0.23	0.29	0.20 U
Nitrate as N	0.02 J	0.20 U	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U		0.01 J	0.20 U	0.02 J	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U		0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS															
pH (SU)	7.03	7.07	7.09	7.09	7.00	7.00	7.02	7.09	7.01	7.07	7.04	7.07	7.09	7.30	7.26
Temperature (^{o}C)	23.27	20.3	21.50	23.19	19.97	21.11	24.04	17.82	13.48	15.3	21.7	22.8	27.9	24.9	19.1
Dissolved Oxygen (DO; mg/L)	0.60	0.17	0.8	0.06	0.12	0.09	0.1	1.22	0.44	0.5	0.39	0.07	0.06	0.23	0
Redox Potential (ORP; mV)	-109.5	-128	-139.3	-138.1	-97.1	-73.5	-93	-117.1	-75.6	-27.8	-84.8	-92.9	-83	-109	-182.7
Specific Conductivity (mS/cm)	0.619	0.619	0.627	0.593	0.526	0.530	0.639	0.637	0.608	0.627	0.644	0.765	0.829	0.655	0.528
Depth to Water (ft-btoc) prior to purging	7.4	7.65	6	7.54	7.72	7.64	7.04	7.11	7.31	6.4	7.31	7.61	6.72	7.67	7.4
Purge Rate (mL/min)	200	300		200	200	200	200	200	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)	6.00E-01 J		5.00E+00 U									1.88E+01		3.80E+00 J	
Propane Monooxygenase (PPO)	4.50E+00 J		1.63E+01									9.80E+00		4.10E+00 J	
Ammonia Monooxygenase (AMO)	4.60E+00 U		5.00E+00 U									1.00E+00 J		1.00E-01 J	
Soluble Methane Monooxygenase (SMMO)	1.03E+03		5.37E+02									4.70E+00 U		4.60E+00 U	
Particulate methane monooxygenase (PMMO)	4.60E+00 U		5.00E+00 U									4.70E+00 U		4.60E+00 U	
Ethene Monooxygenase (EtnC)	4.60E+00 U		5.00E+00 U									4.70E+00 U		4.60E+00 U	
Epoxyalkane transferase (EtnE)	4.60E+00 U		5.00E+00 U									1.79E+01		4.60E+00 U	

Notes:

U - The compound was not detected at the indicated PQL concentration.
J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.
D - Sample was diluted prior to analysis.
E - Estimated value, beyond linear range.
Blank - Not Analyzed.

Sample ID	MB-30		MB-30		MB-30		MB-30		MB-30		MB-30		MB-30		MB-30		MB-30	
Sampling Date	7/18/2019		8/28/2019		10/22/2019		12/8/2019		2/26/2020		5/13/2020		7/13/2020		9/17/2020		12/21/2020	
Days	-5		36		91		138		218		295		356		422		517	
Matrix	Water		Water		Water		Water		Water		Water		Water		Water		Water	
VOCS (GC/MS)	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
dichlorodifluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
vinyl chloride	24.70		25.61		20.43		27.62		17.81		1.93		3.79		10.28		48.84	
bromomethane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
chloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichlorofluoromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	0.43	J
methylene chloride	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
trans-1,2-dichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis 1,2- dichloroethylene	26.12		41.49		26.00		36.23		24.01		6.35		10.90		22.14		42.63	
bromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chloroform	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,1-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
carbon tetrachloride	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
benzene	0.76	J	0.80	J	0.66	J	0.84	J	1.00	U	1.00	U	1.00	U	1.00	U	0.74	J
1,2-dichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trichloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromomethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromodichloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
cis-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
toluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
trans-1,3-dichloropropene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2-trichloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tetrachloroethylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
dibromochloromethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromoethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
chlorobenzene	2.47		3.09		2.05		2.50		2.31		1.00	U	0.81	J	0.97	J	2.43	
1,1,1,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
ethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
xylenes (m/p)	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
o-xylene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
styrene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromoform	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
isopropyl benzene (cumene)	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
bromobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,1,2,2-tetrachloroethane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichloropropane	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
n-propyl benzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
2-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-chlorotoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3,5-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
tert-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,4-trimethylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
sec-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,3-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
4-isopropyltoluene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,4-dichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dichlorobenzene	1.56		1.82		1.22		1.35		1.69		1.14		1.88		1.98		1.00	U
n-butylbenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2-dibromo-3-chloropropane	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
1,2,4-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
hexachlorobutadiene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
naphthalene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
1,2,3-trichlorobenzene	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Methyl tertiary butyl ether	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U
Acetone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
carbon disulfide	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U	2.00	U
2-butanone (MEK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
tetrahydrofuran (THF)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
4-methyl-2-pentanone (MIBK)	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-hexanone	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U
2-chloroethyl vinyl ether	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U	5.00	U

Sample ID	MB-30	MB-30	MB-30	MB-30	MB-30	MB-30	MB-30	MB-30	MB-30
Sampling Date	7/18/2019	8/28/2019	10/22/2019	12/8/2019	2/26/2020	5/13/2020	7/13/2020	9/17/2020	12/21/2020
Days	-5	36	91	138	218	295	356	422	517
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water
1,4-DIOXANE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1,4-Dioxane	1.04								
REDUCED GASES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Methane	205.80	91.13	58.57	174.75	466.94	8.08	54.01	56.65	219.66
Ethane	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U	1.87 U
Ethene	6.18	1.43 J	1.33 J	2.22 U	3.02	2.22 U	2.22 U	2.22 U	3.16
Propane	2.68 U	2.68 U	21.17	75.43	2.34 J	16.68	138.41	43.64	2.68 U
Acetylene	11.89	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U	6.99 U
GROUNDWATER CHEMISTRY	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ammonia as NH3-N	0.105	0.02	0.02 U	0.07	0.13	0.07	0.14	0.18	0.19
ANIONS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chloride	17.75	16.40	19.18	17.34	20.35	20.86	21.26	19.12	20.20
Nitrite as N	0.20 U	0.20 U	0.13 J	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Sulfate as SO4	24.62	99.68	55.65	23.84	29.91	47.90	42.31	39.32	22.44
Bromide	0.83	0.20 U	0.20 U	0.20 U	0.24	0.31	0.35	0.45	0.36
Nitrate as N	0.04 J	0.20 U	0.01 J	0.20 U	0.20 U	0.20 U	0.20 U	0.01 J	0.20 U
Phosphate as P, ortho	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
FIELD PARAMETERS									
pH (SU)	6.86	6.94	6.81	7.03	7.01	6.99	7.14	6.92	7.21
Temperature (^{o}C)	22.58	21.9	25.56	15.20	19.20	21.70	21.20	22.6	19.7
Dissolved Oxygen (DO; mg/L)	0.56	0.16	0.1	0.36	0.18	0.15	0.03	0.03	0
Redox Potential (ORP; mV)	-85.2	-98.5	-66.9	-40.4	-44.5	-31.4	-53.8	3.6	91.6
Specific Conductivity (mS/cm)	0.650	0.827	0.717	0.631	0.594	0.850	0.717	0.630	0.583
Depth to Water (ft-btoc) prior to purging	7.9	8.35	7.6	7.82	6.98	8.10	7.18	8.05	7.91
Purge Rate (mL/min)	200	240	200	200	200	200	200	200	200
Microbial Analyses	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL	cells/mL
Short Chain Alkane monooxygenase (SCAM)									
Propane Monooxygenase (PPO)									
Ammonia Monooxygenase (AMO)									
Soluble Methane Monooxygenase (SMMO)									
Particulate methane monooxygenase (PMMO)									
Ethene Monooxygenase (EtnC)									
Epoxyalkane transferase (EtnE)									

Notes:

U - The compound was not detected at the indicated PQL concentration.

J - Data indicates the presence of a compound that meets the identification criteria. The result is less than the quantitation limit but greater than zero. The concentration given is an approximate value.

D - Sample was diluted prior to analysis.

E - Estimated value, beyond linear range.

Blank - Not Analyzed.

APPENDIX E OXYGEN AND COMETABOLIC GAS SPARGING DATA SUMMARY

Oxygen Sparge Cycle Summary

Cometabolic Treatment of a Large, Dilute Plume
ESTCP Project ER-201629
Former Myrtle Beach Air Force Base, South Carolina

Day	Date	Oxygen Sparge Rate (SCFM)	Duration Per Well (min)	Number of Wells	Number of Cycles	Total Volume (cu. ft.)	Total Mass (lbs)
0	7/23/2019	10	10	22	1	2,200	182.6
-5	7/24/2019	15	3	22	1	990	82.2
-4	7/25/2019	15	4	22	1	1,320	109.6
0	7/29/2019	15	10	22	1	3,300	273.9
3	8/1/2019	10	6	22	1	1,320	109.6
4	8/2/2019	10	4	22	1	880	73.0
9	8/7/2019	12	10	22	1	2,640	219.1
10	8/8/2019	12	10	22	1	2,640	219.1
14	8/12/2019	12	5	22	1	1,320	109.6
15	8/13/2019	10	2	22	6	2,640	219.1
16	8/14/2019	6	2	22	1	264	21.9
16	8/14/2019	10	1	22	3	660	54.8
16	8/14/2019	7	1	22	1	154	12.8
18	8/16/2019	10	2	22	5	2,200	182.6
18	8/16/2019	15	2	22	3	1,980	164.3
21	8/19/2019	15	1.5	22	2	990	82.2
21	8/19/2019	10	2	22	1	440	36.5
28	8/26/2019	6	2	22	3	792	65.7
28	8/26/2019	12	2	22	1	528	43.8
33	8/31/2019	12	2	22	3	1,584	131.5
36	9/3/2019	12	2	22	2	1,056	87.6
36	9/3/2019	10	2	22	1	440	36.5
42	9/9/2019	10	2	22	3	1,320	109.6
42	9/9/2019	12	2	22	2	1,056	87.6
42	9/9/2019	15	2	22	1	660	54.8
49	9/16/2019	12	3	22	3	2,376	197.2
50	9/17/2019	12	3	22	3	2,376	197.2
53	9/20/2019	12	3	22	1	792	65.7
53	9/20/2019	7.5	3	22	1	495	41.1
65	10/2/2019	12	3	22	2	1,584	131.5
66	10/3/2019	12	3	22	1	792	65.7
66	10/3/2019	10	2	22	4	1,760	146.1
67	10/4/2019	10	2	22	1	440	36.5
67	10/4/2019	10	3	22	1	660	54.8
67	10/4/2019	7	2	22	1	308	25.6
71	10/8/2019	12	3	22	5	3,960	328.7
73	10/10/2019	12	3	22	2	1,584	131.5
78	10/15/2019	12	3	22	2	1,584	131.5
88	10/25/2019	12	3	22	1	792	65.7
88	10/25/2019	9	3	22	1	594	49.3
88	10/25/2019	6	3	22	1	396	32.9
91	10/28/2019	6	3	22	2	792	65.7
98	11/4/2019	8	2	22	1	352	29.2
98	11/4/2019	10	3	22	1	660	54.8
98	11/4/2019	10	3	22	1	660	54.8
102	11/8/2019	12	3	22	1	792	65.7
102	11/8/2019	12	3	22	1	792	65.7
104	11/10/2019	12	3	22	1	792	65.7
109	11/15/2019	12	3	22	1	792	65.7
112	11/18/2019	12	3	22	1	792	65.7
112	11/18/2019	12	3	22	1	792	65.7
130	12/6/2019	12	3	22	1	792	65.7
130	12/6/2019	10	5	22	1	1,100	91.3
130	12/6/2019	10	5	22	1	1,100	91.3
134	12/10/2019	12	3	22	1	792	65.7
134	12/10/2019	15	5	22	1	1,650	137.0
140	12/16/2019	15	5	22	1	1,650	137.0
154	12/30/2019	15	3	22	1	990	82.2
154	12/30/2019	15	5	22	1	1,650	137.0
157	1/2/2020	15	3	22	1	990	82.2
161	1/6/2020	15	5	22	1	1,650	137.0

Day	Date	Oxygen Sparge Rate (SCFM)	Duration Per Well (min)	Number of Wells	Number of Cycles	Total Volume (cu. ft.)	Total Mass (lbs)
165	1/10/2020	9	5	22	1	990	82.2
175	1/20/2020	10	5	22	1	1,100	91.3
176	1/21/2020	7	4	22	1	616	51.1
179	1/24/2020	15	5	22	1	1,650	137.0
182	1/27/2020	15	5	22	1	1,650	137.0
189	2/3/2020	15	5	22	1	1,650	137.0
196	2/10/2020	15	5	22	1	1,650	137.0
203	2/17/2020	12	5	22	1	1,320	109.6
210	2/24/2020	12	5	22	1	1,320	109.6
217	3/2/2020	8	4	22	1	704	58.4
227	3/12/2020	10.5	4	22	1	924	76.7
235	3/20/2020	12	4	22	1	1,056	87.6
239	3/24/2020	12	4	22	1	1,056	87.6
245	3/30/2020	12	4	22	1	1,056	87.6
252	4/6/2020	12	4	22	1	1,056	87.6
259	4/13/2020	12	4	22	1	1,056	87.6
266	4/20/2020	12	5	22	1	1,320	109.6
273	4/27/2020	14.5	5	22	1	1,595	132.4
277	5/1/2020	7	3	22	1	462	38.3
280	5/4/2020	10	5	22	1	1,100	91.3
283	5/7/2020	8	3	22	1	528	43.8
284	5/8/2020	8	2	22	1	352	29.2
291	5/15/2020	7	5	22	1	770	63.9
297	5/21/2020	10	5	22	1	1,100	91.3
302	5/26/2020	10	2	22	1	440	36.5
302	5/26/2020	10	5	22	1	1,100	91.3
303	5/27/2020	10	3	22	1	660	54.8
308	6/1/2020	10	5	22	1	1,100	91.3
309	6/2/2020	12	5	6	1	360	29.9
312	6/5/2020	12	5	6	1	360	29.9
309	6/2/2020	10	5	22	1	1,100	91.3
322	6/15/2020	10	5	22	1	1,100	91.3
323	6/16/2020	15	5	6	1	450	37.4
330	6/23/2020	15	5	6	1	450	37.4
332	6/25/2020	12	5	22	1	1,320	109.6
336	6/29/2020	10	5	22	1	1,100	91.3
343	7/6/2020	10	5	22	1	1,100	91.3
346	7/9/2020	9	4	22	1	792	65.7
351	7/14/2020	10	5	22	1	1,100	91.3
357	7/20/2020	13	5	6	1	390	32.4
359	7/22/2020	10	5	22	1	1,100	91.3
365	7/28/2020	10	5	22	1	1,100	91.3
371	8/3/2020	10	5	22	1	1,100	91.3
373	8/5/2020	10	5	22	1	1,100	91.3
379	8/11/2020	12	5	6	1	360	29.9
380	8/12/2020	12	5	6	1	360	29.9
380	8/12/2020	10	5	6	1	300	24.9
380	8/12/2020	10	4	22	1	880	73.0
386	8/18/2020	10	5	22	1	1,100	91.3
391	8/23/2020	8	5	6	1	240	19.9
393	8/25/2020	8	5	22	1	880	73.0
399	8/31/2020	10	5	22	1	1,100	91.3
400	9/1/2020	12	5	6	1	360	29.9
401	9/2/2020	12	5	6	1	360	29.9
406	9/7/2020	12	5	6	1	360	29.9
406	9/7/2020	10	5	22	1	1,100	91.3
408	9/9/2020	12	5	6	1	360	29.9
409	9/10/2020	12	5	6	1	360	29.9
410	9/11/2020	12	5	6	1	360	29.9
413	9/14/2020	15	5	6	1	450	37.4
406	9/7/2020	10	5	22	1	1,100	91.3
					Project Total	**126,880**	**10,531**

Cometabolic Gas Sparge Cycle Summary

Cometabolic Treatment of a Large, Dilute Plume
ESTCP Project ER-201629
Former Myrtle Beach Air Force Base, South Carolina

Day	Date	Total Sparge Rate (SCFM)	Propane Sparge Rate (SCFM)	Ammonia Sparge Rate (SCFM)	Nitrogen Sparge Rate (SCFM)	Number of wells	Duration Per Well (min)	Number of Cycles	Total Volume (cu. ft.)	Total Volume Propane (cu. ft.)	Total Volume Ammonia (cu. ft.)	Total Volume Nitrogen (cu. ft.)	Total Mass Propane (lbs)	Total Mass Ammonia (lbs)	Total Mass Nitrogen (lbs)
68	9/29/2019	12	1.8	0.4	9.8	22	5	1	1,320.0	198.0	44.0	1,078.0	22.6	1.9	78.0
73	10/4/2019	8.98	1.5	0.75	6.73	22	2	1	395.0	66.0	33.0	296.0	7.5	1.5	21.4
120	11/20/2019	10	2.5	0.75	6.75	22	5	1	1,100.0	275.0	82.5	742.5	31.4	3.6	53.8
174	1/13/2020	8	0.5	0.75	6.75	22	5	1	880.0	55.0	82.5	742.5	6.3	3.6	53.8
189	1/28/2020	8	0.5	0.75	6.75	22	5	1	880.0	55.0	82.5	742.5	6.3	3.6	53.8
196	2/4/2020	8	0.5	0.75	6.75	22	5	1	880.0	55.0	82.5	742.5	6.3	3.6	53.8
204	2/12/2020	7	0.5	0.75	5.75	22	4.32	1	665.0	47.5	71.2	546.2	5.4	3.1	39.5
223	3/2/2020	8	1	0.75	6.25	22	5	1	880.0	110.0	82.5	687.5	12.5	3.6	49.8
247	3/26/2020	8	1	0.75	6.25	22	5	1	880.0	110.0	82.5	687.5	12.5	3.6	49.8
255	4/3/2020	7.5	1	0	6.5	22	5	1	825.0	110.0	0.0	715.0	12.5	0.0	51.8
262	4/10/2020	8	1	0.75	6.25	22	4.7	1	827.2	103.4	77.6	646.3	11.8	3.4	46.8
269	4/17/2020	8	1	0.75	6.25	22	5	1	880.0	110.0	82.5	687.5	12.5	3.6	49.8
274	4/22/2020	8	1	0.75	6.25	22	5	1	880.0	110.0	82.5	687.5	12.5	3.6	49.8
280	4/28/2020	8	1	0.75	6.25	22	5	1	880.0	110.0	82.5	687.5	12.5	3.6	49.8
295	5/13/2020	8	2	0.75	5.25	22	5	1	880.0	220.0	82.5	577.5	25.1	3.6	41.8
309	5/27/2020	8	2	0.75	5.25	22	5	1	880.0	220.0	82.5	577.5	25.1	3.6	41.8
325	6/12/2020	8	2	0.75	5.25	22	5	1	880.0	220.0	82.5	577.5	25.1	3.6	41.8
331	6/18/2020	8	2	0.75	5.25	6	5	1	240.0	60.0	22.5	157.5	6.8	1.0	11.4
344	7/1/2020	8	2	0.75	5.25	22	5	1	880.0	220.0	82.5	577.5	25.1	3.6	41.8
360	7/17/2020	8	2	0.75	5.25	22	5	1	880.0	220.0	82.5	577.5	25.1	3.6	41.8
364	7/21/2020	8	2	0.75	5.25	6	5	1	240.0	60.0	22.5	157.5	6.8	1.0	11.4
387	8/13/2020	7.5	0.75	0.25	6.5	22	5	1	825.0	82.5	27.5	715.0	9.4	1.2	51.8
394	8/20/2020	7.5	0.75	0.25	6.5	22	5	1	825.0	82.5	27.5	715.0	9.4	1.2	51.8
402	8/28/2020	7.5	0.75	0.25	6.5	22	5	1	825.0	82.5	27.5	715.0	9.4	1.2	51.8
412	9/7/2020	7.5	0.75	0.25	6.5	22	5	1	825.0	82.5	27.5	715.0	9.4	1.2	51.8
								Project Total	**20,352.2**	**3,064.9**	**1,535.8**	**15,751.5**	**349.4**	**67.6**	**1,140.4**

APPENDIX F GROUNDWATER MONITORING EVENT SUMMARY TABLES

Baseline Sampling Event
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**	**Census (qPCR)**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**Microbial Insights**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM	No Preservative
Bottleware	Three 40 mL	Three 40 mL	Two 40 mL	One 15 mL conical	One 120mL poly	One 1000 mL
Monitoring Wells & Electrode Wells						
PMW-0-1	X	X	X	X	X	
PMW-0-2	X	X	X	X	X	
PMW-0-3	X	X	X	X	X	X
PMW-0-4	X	X	X	X	X	X
PMW-1-1	X	X	X	X	X	
PMW-1-2	X	X	X	X	X	
PMW-1-3	X	X	X	X	X	X
PMW-1-4	X	X	X	X	X	
PMW-2-1	X	X	X	X	X	
PMW-2-2	X	X	X	X	X	
PMW-2-3	X	X	X	X	X	
PMW-2-4	X	X	X	X	X	
PMW-3-1	X	X	X	X	X	
PMW-3-2	X	X	X	X	X	
PMW-3-3	X	X	X	X	X	
PMW-3-4	X	X	X	X	X	
PMW-1S	X	X	X	X	X	
PMW-1I	X	X	X	X	X	
PMW-1D	X*	X*	X*	X*	X*	
PMW-2I	X	X	X	X	X	
PMW-2D	X	X	X	X	X	
PMW-3I	X	X	X	X	X	
PMW-3D	X	X	X	X	X	
PMW-4D	X	X	X	X	X	
BMW-1I	X	X	X	X	X	
BMW-1D	X*	X*	X*	X*	X*	X
MB-30	X	X	X	X	X	
Subtotal	**27**	**27**	**27**	**27**	**27**	**4**
Bottleware						
*Field Duplicate**	2	2	2	2	2	0
Trip Blanks	3	0	0	0	0	0
Sample Total*	32	29	29	29	29	4
Bottleware Total	**96**	**87**	**58**	**29**	**29**	**4**

*Collect field duplicate at PMW-1D and BMW-1D

**Includes QA/QC samples.

-Collect field parameters (Temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purging.

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Oxygen Sparging Only Sampling Event
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**	**Dissolved Iron and Manganese**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**Chemtech**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM	EPA 6010D/ Nitric Acid/ Field Filtered
Bottleware	Three 40 mL	Three 40 mL	Two 40 mL	One 15 mL conical	One 120mL poly	One 500 mL
Monitoring Wells & Electrode Wells						
PMW-0-1	X		X	X	X	
PMW-0-2	X		X	X	X	
PMW-0-3	X		X	X	X	
PMW-0-4	X	X	X	X	X	X
PMW-1-1	X		X	X	X	
PMW-1-2	X		X	X	X	
PMW-1-3	X	X	X	X	X	X
PMW-1-4	X	X	X	X	X	X
PMW-2-1	X		X	X	X	
PMW-2-2	X		X	X	X	
PMW-2-3	X		X	X	X	
PMW-2-4	X	X	X	X	X	
PMW-3-1	X		X	X	X	
PMW-3-2	X		X	X	X	
PMW-3-3	X		X	X	X	
PMW-3-4	X	X	X	X	X	
PMW-1S	X		X	X	X	
PMW-1I	X		X	X	X	
PMW-1D	X*	X*	X*	X*	X*	
PMW-2I	X		X	X	X	
PMW-2D	X		X	X	X	
PMW-3I	X		X	X	X	
PMW-3D	X		X	X	X	
PMW-4D	X	X	X	X	X	
BMW-1I	X		X	X	X	X
BMW-1D	X*	X	X*	X*	X*	X
MB-30	X		X	X	X	
Subtotal	**27**	**8**	**27**	**27**	**27**	**5**
Bottleware						
*Field Duplicate**	2	1	2	2	2	0
Trip Blanks	3	0	0	0	0	0
Sample Total**	32	9	29	29	29	5
Bottleware Total	**96**	**27**	**58**	**29**	**29**	**5**

*Collect field duplicate at PMW-1D and BMW-1D

**Includes QA/QC samples.

-Collect field parameters (Temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purging.

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Pre-Substrate Addition Sampling Event
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**	**Census (qPCR)**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**Microbial Insights**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM	No Preservative
Bottleware	Three 40 mL	Three 40 mL	Two 40 mL	One 15 mL conical	One 120mL poly	One 1000 mL
Monitoring Wells & Electrode Wells						
PMW-0-1						
PMW-0-2						
PMW-0-3	X	X	X	X		X
PMW-0-4	X	X	X	X		X
PMW-1-1						
PMW-1-2						
PMW-1-3	X	X	X	X		X
PMW-1-4						
PMW-2-1						
PMW-2-2						
PMW-2-3						
PMW-2-4						
PMW-3-1						
PMW-3-2						
PMW-3-3						
PMW-3-4						
PMW-1S						
PMW-1I						
PMW-1D						
PMW-2I						
PMW-2D						
PMW-3I						
PMW-3D						
PMW-4D						
BMW-1I						
BMW-1D	X*	X*	X*	X*		X
MB-30						
Subtotal	**4**	**4**	**4**	**4**	**0**	**4**
Bottleware						
*Field Duplicate**	1	1	1	1	0	0
Trip Blanks	1	0	0	0	0	0
Sample Total**	6	5	5	5	0	4
Bottleware Total	**18**	**15**	**10**	**5**	**0**	**4**

*Collect field duplicate at PMW-1D

**Includes QA/QC samples.

-Collect field parameters (Temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purging.

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Dissolved Propane and Total Ammonia Sampling Event #1
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Two 40 mL	One 15 mL conical	One 120mL poly
Monitoring Wells & Electrode Wells					
PMW-0-1					
PMW-0-2			X		X
PMW-0-3			X		X
PMW-0-4			X		X
PMW-1-1					
PMW-1-2			X		X
PMW-1-3			X		X
PMW-1-4			X		X
PMW-2-1					
PMW-2-2					
PMW-2-3					
PMW-2-4					
PMW-3-1					
PMW-3-2					
PMW-3-3					
PMW-3-4					
PMW-1S					
PMW-1I					
PMW-1D					
PMW-2I					
PMW-2D					
PMW-3I					
PMW-3D					
PMW-4D					
BMW-1I			X		X
BMW-1D			X*		X*
MB-30					
Subtotal	**0**	**0**	**8**	**0**	**8**
Bottleware					
*Field Duplicate**	0	0	1	0	1
Trip Blanks	0	0	0	0	0
Sample Total*	0	0	9	0	9
Bottleware Total	**0**	**0**	**18**	**0**	**9**

*Collect field duplicate at PMW-1D

**Includes QA/QC samples.

-Collect field parameters (Temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Dissolved Propane and Total Ammonia Sampling Event #2
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Two 40 mL	One 15 mL conical	One 120mL poly
Monitoring Wells & Electrode Wells					
PMW-0-1					
PMW-0-2			X	X	X
PMW-0-3			X	X	X
PMW-0-4			X	X	X
PMW-1-1					
PMW-1-2			X	X	X
PMW-1-3			X	X	X
PMW-1-4			X	X	X
PMW-2-1					
PMW-2-2					
PMW-2-3					
PMW-2-4					
PMW-3-1					
PMW-3-2					
PMW-3-3					
PMW-3-4					
PMW-1S					
PMW-1I					
PMW-1D					
PMW-2I					
PMW-2D					
PMW-3I					
PMW-3D					
PMW-4D					
BMW-1I			X	X	X
BMW-1D			X*	X*	X*
MB-30					
Subtotal	**0**	**0**	**8**	**8**	**8**
Bottleware					
*Field Duplicate**	0	0	1	1	1
Trip Blanks	0	0	0	0	0
Sample Total*	0	0	9	9	9
Bottleware Total	**0**	**0**	**18**	**9**	**9**

*Collect field duplicate at BMW-1D

**Includes QA/QC samples.

-Collect field parameters (Temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Dissolved Propane and Total Ammonia Sampling Event #3
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Two 40 mL	One 15 mL conical	One 120mL poly
Monitoring Wells & Electrode Wells					
PMW-0-1					
PMW-0-2			X	X	X
PMW-0-3			X	X	X
PMW-0-4			X	X	X
PMW-1-1					
PMW-1-2			X	X	X
PMW-1-3			X	X	X
PMW-1-4			X	X	X
PMW-2-1					
PMW-2-2					
PMW-2-3					
PMW-2-4					
PMW-3-1					
PMW-3-2					
PMW-3-3					
PMW-3-4					
PMW-1S					
PMW-1I					
PMW-1D					
PMW-2I					
PMW-2D					
PMW-3I					
PMW-3D					
PMW-4D					
BMW-1I			X	X	X
BMW-1D			X*	X*	X*
MB-30					
Subtotal	**0**	**0**	**8**	**8**	**8**
Bottleware					
*Field Duplicate**	0	0	1	1	1
Trip Blanks	0	0	0	0	0
Sample Total*	0	0	9	9	9
Bottleware Total	**0**	**0**	**18**	**9**	**9**

*Collect field duplicate at BMW-1D

**Includes QA/QC samples.

-Collect field parameters (Temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Dissolved Propane and Total Ammonia Sampling Event #4
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Two 40 mL	One 15 mL conical	One 50mL conical
Monitoring Wells & Electrode Wells					
PMW-0-1					
PMW-0-2	X		X	X	X
PMW-0-3	X		X	X	X
PMW-0-4	X		X	X	X
PMW-1-1					
PMW-1-2	X		X	X	X
PMW-1-3	X		X	X	X
PMW-1-4	X		X	X	X
PMW-2-1					
PMW-2-2					
PMW-2-3	X		X	X	X
PMW-2-4	X		X	X	X
PMW-3-1					
PMW-3-2					
PMW-3-3	X		X	X	X
PMW-3-4	X		X	X	X
PMW-1S					
PMW-1I					
PMW-1D					
PMW-2I					
PMW-2D					
PMW-3I					
PMW-3D					
PMW-4D					
BMW-1I					
BMW-1D	X*		X*	X*	X*
MB-30					
Subtotal	**11**	**0**	**11**	**11**	**11**
Bottleware					
*Field Duplicate**	1	0	1	1	1
Trip Blanks	1	0	0	0	0
Sample Total	13	0	12	12	12
Bottleware Total	**39**	**0**	**24**	**12**	**12**

*Collect field duplicate at BMW-1D

**Includes QA/QC samples.

-Collect field parameters (temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purgi

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Performance Sampling Event #1
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Two 40 mL	One 15 mL conical	One 120mL poly
Monitoring Wells & Electrode Wells					
PMW-0-1	X		X	X	X
PMW-0-2	X		X	X	X
PMW-0-3	X		X	X	X
PMW-0-4	X	X	X	X	X
PMW-1-1	X		X	X	X
PMW-1-2	X		X	X	X
PMW-1-3	X	X	X	X	X
PMW-1-4	X	X	X	X	X
PMW-2-1	X		X	X	X
PMW-2-2	X		X	X	X
PMW-2-3	X		X	X	X
PMW-2-4	X	X	X	X	X
PMW-3-1	X		X	X	X
PMW-3-2	X		X	X	X
PMW-3-3	X		X	X	X
PMW-3-4	X	X	X	X	X
PMW-1S	X		X	X	X
PMW-1I	X		X	X	X
PMW-1D	X*	X*	X*	X*	X*
PMW-2I	X		X	X	X
PMW-2D	X		X	X	X
PMW-3I	X		X	X	X
PMW-3D	X		X	X	X
PMW-4D	X	X	X	X	X
BMW-1I	X		X	X	X
BMW-1D	X*	X	X*	X*	X*
MB-30	X		X	X	X
Subtotal	**27**	**8**	**27**	**27**	**27**
Bottleware					
*Field Duplicate**	2	1	2	2	2
Trip Blanks	3	0	0	0	0
Sample Total*	32	9	29	29	29
Bottleware Total	**96**	**27**	**58**	**29**	**29**

*Collect field duplicate at PMW-1D and BMW-1D

**Includes QA/QC samples.

-Collect field parameters (Temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Dissolved Propane and Total Ammonia Sampling Event #5
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Two 40 mL	One 15 mL conical	One 50mL conical
Monitoring Wells & Electrode Wells					
PMW-0-1					
PMW-0-2			X		X
PMW-0-3			X		X
PMW-0-4			X		X
PMW-1-1					
PMW-1-2			X		X
PMW-1-3			X		X
PMW-1-4			X		X
PMW-2-1					
PMW-2-2			X		X
PMW-2-3			X		X
PMW-2-4			X		X
PMW-3-1					
PMW-3-2					
PMW-3-3					
PMW-3-4					
PMW-1S					
PMW-1I					
PMW-1D					
PMW-2I					
PMW-2D					
PMW-3I					
PMW-3D					
PMW-4D					
BMW-1I					
BMW-1D					
MB-30					
Subtotal	**0**	**0**	**9**	**0**	**9**
Bottleware					
*Field Duplicate**	0	0	0	0	0
Trip Blanks	0	0	0	0	0
Sample Total*	0	0	9	0	9
Bottleware Total	**0**	**0**	**18**	**0**	**9**

*No field duplicate collected

**Includes QA/QC samples.

-Collect field parameters (temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purgi

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Performance Sampling Event #2
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Two 40 mL	One 15 mL conical	One 120mL poly
Monitoring Wells					
PMW-0-1	X		X	X	X
PMW-0-2	X		X	X	X
PMW-0-3	X		X	X	X
PMW-0-4	X	X	X	X	X
PMW-1-1	X		X	X	X
PMW-1-2	X		X	X	X
PMW-1-3	X	X	X	X	X
PMW-1-4	X	X	X	X	X
PMW-2-1	X		X	X	X
PMW-2-2	X		X	X	X
PMW-2-3	X		X	X	X
PMW-2-4	X	X	X	X	X
PMW-3-1	X		X	X	X
PMW-3-2	X		X	X	X
PMW-3-3	X		X	X	X
PMW-3-4	X	X	X	X	X
PMW-1S	X		X	X	X
PMW-1I	X		X	X	X
PMW-1D	X*	X*	X*	X*	X*
PMW-2I	X		X	X	X
PMW-2D	X		X	X	X
PMW-3I	X		X	X	X
PMW-3D	X		X	X	X
PMW-4D	X	X	X	X	X
BMW-1I	X		X	X	X
BMW-1D	X*	X	X*	X*	X*
MB-30	X		X	X	X
Subtotal	**27**	**8**	**27**	**27**	**27**
Bottleware					
*Field Duplicate**	2	1	2	2	2
Trip Blanks	3	0	0	0	0
Sample Total*	32	9	29	29	29
Bottleware Total	**96**	**27**	**58**	**29**	**29**

*Collect field duplicate at PMW-1D and BMW-1D

**Includes QA/QC samples.

-Collect field parameters (Temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Dissolved Propane and Total Ammonia Sampling Event #6
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Two 40 mL	One 15 mL conical	One 50mL conical
Monitoring Wells					
PMW-0-1					
PMW-0-2			X		X
PMW-0-3			X		X
PMW-0-4			X		X
PMW-1-1			X*		X*
PMW-1-2			X		X
PMW-1-3			X		X
PMW-1-4			X		X
PMW-2-1					
PMW-2-2			X		X
PMW-2-3			X		X
PMW-2-4			X		X
PMW-3-1					
PMW-3-2					
PMW-3-3					
PMW-3-4					
PMW-1S					
PMW-1I					
PMW-1D					
PMW-2I					
PMW-2D					
PMW-3I					
PMW-3D					
PMW-4D					
BMW-1I					
BMW-1D					
MB-30					
Subtotal	**0**	**0**	**10**	**0**	**10**
Bottleware					
*Field Duplicate**	0	0	1	0	1
Trip Blanks	0	0	0	0	0
Sample Total**	0	0	11	0	11
Bottleware Total	**0**	**0**	**22**	**0**	**11**

*Collect field duplicate at PMW-1.1

**Includes QA/QC samples.

-Collect field parameters (temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purgi

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Dissolved Propane and Total Ammonia Sampling Event #7
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Three 40 mL	One 15 mL conical	One 50mL conical
Monitoring Wells					
PMW-0-1					
PMW-0-2			X		X
PMW-0-3			X		X
PMW-0-4			X		X
PMW-1-1			X		X
PMW-1-2			X		X
PMW-1-3			X*		X*
PMW-1-4			X		X
PMW-2-1					
PMW-2-2			X		X
PMW-2-3			X		X
PMW-2-4			X		X
PMW-3-1					
PMW-3-2					
PMW-3-3					
PMW-3-4					
PMW-1S					
PMW-1I					
PMW-1D					
PMW-2I					
PMW-2D					
PMW-3I					
PMW-3D					
PMW-4D					
BMW-1I					
BMW-1D					
MB-30					
Subtotal	**0**	**0**	**10**	**0**	**10**
Bottleware					
*Field Duplicate**	0	0	1	0	1
Trip Blanks	0	0	0	0	0
Sample Total**	0	0	11	0	11
Bottleware Total	**0**	**0**	**33**	**0**	**11**

*Collect field duplicate at PMW-1-3.

**Includes QA/QC samples.

-Collect field parameters (temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purgi

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Dissolved Propane and Total Ammonia Sampling Event #8
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Three 40 mL	One 15 mL conical	One 50mL conical
Monitoring Wells					
PMW-0-1					
PMW-0-2			X		X
PMW-0-3			X		X
PMW-0-4			X		X
PMW-1-1			X		X
PMW-1-2			X		X
PMW-1-3			X*		X*
PMW-1-4			X		X
PMW-2-1					
PMW-2-2			X		X
PMW-2-3			X		X
PMW-2-4			X		X
PMW-3-1					
PMW-3-2			X		X
PMW-3-3					
PMW-3-4					
PMW-1S					
PMW-1I					
PMW-1D					
PMW-2I					
PMW-2D					
PMW-3I					
PMW-3D					
PMW-4D					
BMW-1I					
BMW-1D					
MB-30					
Subtotal	**0**	**0**	**11**	**0**	**11**
Bottleware					
*Field Duplicate**	0	0	1	0	1
Trip Blanks	0	0	0	0	0
Sample Total	0	0	12	0	12
Bottleware Total	**0**	**0**	**36**	**0**	**12**

*Collect field duplicate at PMW-1-3.

**Includes QA/QC samples.

-Collect field parameters (temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purgi

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Dissolved Propane and Total Ammonia Sampling Event #9
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Three 40 mL	One 15 mL conical	One 50mL conical
Monitoring Wells					
PMW-0-1					
PMW-0-2			X		X
PMW-0-3			X		X
PMW-0-4			X		X
PMW-1-1			X		X
PMW-1-2			X		X
PMW-1-3			X*		X*
PMW-1-4			X		X
PMW-2-1					
PMW-2-2			X		X
PMW-2-3			X		X
PMW-2-4			X		X
PMW-3-1					
PMW-3-2			X		X
PMW-3-3					
PMW-3-4					
PMW-1S					
PMW-1I					
PMW-1D					
PMW-2I					
PMW-2D					
PMW-3I					
PMW-3D					
PMW-4D					
BMW-1I					
BMW-1D					
MB-30					
Subtotal	**0**	**0**	**11**	**0**	**11**
Bottleware					
*Field Duplicate**	0	0	1	0	1
Trip Blanks	0	0	0	0	0
Sample Total*	0	0	12	0	12
Bottleware Total	**0**	**0**	**36**	**0**	**12**

*Collect field duplicate at PMW-1-3.

**Includes QA/QC samples.

-Collect field parameters (temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purgi

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Dissolved Propane and Total Ammonia Sampling Event #10
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Three 40 mL	One 15 mL conical	One 50mL conical
Monitoring Wells					
PMW-0-1					
PMW-0-2			X		X
PMW-0-3			X		X
PMW-0-4			X		X
PMW-1-1			X		X
PMW-1-2			X		X
PMW-1-3			X*		X*
PMW-1-4			X		X
PMW-2-1					
PMW-2-2			X		X
PMW-2-3			X		X
PMW-2-4			X		X
PMW-3-1					
PMW-3-2			X		X
PMW-3-3					
PMW-3-4					
PMW-1S					
PMW-1I					
PMW-1D					
PMW-2I					
PMW-2D					
PMW-3I					
PMW-3D					
PMW-4D					
BMW-1I					
BMW-1D					
MB-30					
Subtotal	**0**	**0**	**11**	**0**	**11**
Bottleware					
*Field Duplicate**	0	0	1	0	1
Trip Blanks	0	0	0	0	0
Sample Total*	0	0	12	0	12
Bottleware Total	**0**	**0**	**36**	**0**	**12**

*Collect field duplicate at PMW-1-3.

**Includes QA/QC samples.

-Collect field parameters (temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purgi

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Dissolved Propane and Total Ammonia Sampling Event #11
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Three 40 mL	One 15 mL conical	One 50mL conical
Monitoring Wells					
PMW-0-1					
PMW-0-2			X		X
PMW-0-3			X		X
PMW-0-4			X		X
PMW-1-1			X		X
PMW-1-2			X		X
PMW-1-3			X*		X*
PMW-1-4			X		X
PMW-2-1					
PMW-2-2			X		X
PMW-2-3			X		X
PMW-2-4			X		X
PMW-3-1					
PMW-3-2			X		X
PMW-3-3					
PMW-3-4					
PMW-1S					
PMW-1I					
PMW-1D					
PMW-2I					
PMW-2D					
PMW-3I					
PMW-3D					
PMW-4D					
BMW-1I					
BMW-1D					
MB-30					
Subtotal	**0**	**0**	**11**	**0**	**11**
Bottleware					
*Field Duplicate**	0	0	1	0	1
Trip Blanks	0	0	0	0	0
Sample Total*	0	0	12	0	12
Bottleware Total	**0**	**0**	**36**	**0**	**12**

*Collect field duplicate at PMW-1-3.

**Includes QA/QC samples.

-Collect field parameters (temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purgi

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Dissolved Propane and Total Ammonia Sampling Event #12
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Three 40 mL	One 15 mL conical	One 50mL conical
Monitoring Wells					
PMW-0-1					
PMW-0-2			X		X
PMW-0-3			X		X
PMW-0-4			X		X
PMW-1-1			X		X
PMW-1-2			X		X
PMW-1-3			X*		X*
PMW-1-4			X		X
PMW-2-1					
PMW-2-2			X		X
PMW-2-3			X		X
PMW-2-4			X		X
PMW-3-1					
PMW-3-2			X		X
PMW-3-3					
PMW-3-4					
PMW-1S					
PMW-1I					
PMW-1D					
PMW-2I					
PMW-2D					
PMW-3I					
PMW-3D					
PMW-4D					
BMW-1I					
BMW-1D					
MB-30					
Subtotal	**0**	**0**	**11**	**0**	**11**
Bottleware					
*Field Duplicate**	0	0	1	0	1
Trip Blanks	0	0	0	0	0
Sample Total*	0	0	12	0	12
Bottleware Total	**0**	**0**	**36**	**0**	**12**

*Collect field duplicate at PMW-1-3.

**Includes QA/QC samples.

-Collect field parameters (temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purgi

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Dissolved Propane and Total Ammonia Sampling Event #13
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Three 40 mL	One 15 mL conical	One 50mL conical
Monitoring Wells					
PMW-0-1					
PMW-0-2			X		X
PMW-0-3			X		X
PMW-0-4			X		X
PMW-1-1			X		X
PMW-1-2			X		X
PMW-1-3			X*		X*
PMW-1-4			X		X
PMW-2-1					
PMW-2-2			X		X
PMW-2-3			X		X
PMW-2-4			X		X
PMW-3-1					
PMW-3-2			X		X
PMW-3-3					
PMW-3-4					
PMW-1S					
PMW-1I					
PMW-1D					
PMW-2I					
PMW-2D					
PMW-3I					
PMW-3D					
PMW-4D					
BMW-1I					
BMW-1D					
MB-30					
Subtotal	**0**	**0**	**11**	**0**	**11**
Bottleware					
*Field Duplicate**	0	0	1	0	1
Trip Blanks	0	0	0	0	0
Sample Total*	0	0	12	0	12
Bottleware Total	**0**	**0**	**36**	**0**	**12**

*Collect field duplicate at PMW-1-3.

**Includes QA/QC samples.

-Collect field parameters (temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purgi

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Performance Sampling Event #2
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Two 40 mL	One 15 mL conical	One 120mL poly
Monitoring Wells					
PMW-0-1	X		X	X	X
PMW-0-2	X		X	X	X
PMW-0-3	X		X	X	X
PMW-0-4	X	X	X	X	X
PMW-1-1	X		X	X	X
PMW-1-2	X		X	X	X
PMW-1-3	X	X	X	X	X
PMW-1-4	X	X	X	X	X
PMW-2-1	X		X	X	X
PMW-2-2	X		X	X	X
PMW-2-3	X		X	X	X
PMW-2-4	X	X	X	X	X
PMW-3-1	X		X	X	X
PMW-3-2	X		X	X	X
PMW-3-3	X		X	X	X
PMW-3-4	X	X	X	X	X
PMW-1S	X		X	X	X
PMW-1I	X		X	X	X
PMW-1D	X*	X*	X*	X*	X*
PMW-2I	X		X	X	X
PMW-2D	X		X	X	X
PMW-3I	X		X	X	X
PMW-3D	X		X	X	X
PMW-4D	X		X	X	X
BMW-1I	X		X	X	X
BMW-1D	X*	X	X*	X*	X*
MB-30	X		X	X	X
Subtotal	**27**	**7**	**27**	**27**	**27**
Bottleware					
*Field Duplicate**	2	1	2	2	2
Trip Blanks	3	0	0	0	0
Sample Total**	32	8	29	29	29
Bottleware Total	**96**	**24**	**58**	**29**	**29**

*Collect field duplicate at PMW-1D and BMW-1D

**Includes QA/QC samples.

-Collect field parameters (Temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Dissolved Propane and Total Ammonia Sampling Event #14
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Three 40 mL	One 15 mL conical	One 50mL conical
Monitoring Wells					
PMW-0-1					
PMW-0-2			X		X
PMW-0-3			X		X
PMW-0-4			X		X
PMW-1-1			X		X
PMW-1-2			X		X
PMW-1-3			X*		X*
PMW-1-4			X		X
PMW-2-1					
PMW-2-2			X		X
PMW-2-3			X		X
PMW-2-4			X		X
PMW-3-1					
PMW-3-2			X		X
PMW-3-3					
PMW-3-4					
PMW-1S					
PMW-1I					
PMW-1D					
PMW-2I					
PMW-2D					
PMW-3I					
PMW-3D					
PMW-4D					
BMW-1I					
BMW-1D					
MB-30					
Subtotal	**0**	**0**	**11**	**0**	**11**
Bottleware					
*Field Duplicate**	0	0	1	0	1
Trip Blanks	0	0	0	0	0
Sample Total**	0	0	12	0	12
Bottleware Total	**0**	**0**	**36**	**0**	**12**

*Collect field duplicate at PMW-1-3.

**Includes QA/QC samples.

-Collect field parameters (temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purgi

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Dissolved Propane and Total Ammonia Sampling Event #15
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Three 40 mL	One 15 mL conical	One 50mL conical
Monitoring Wells					
PMW-0-1					
PMW-0-2	X		X		X
PMW-0-3	X		X		X
PMW-0-4	X		X		X
PMW-1-1					
PMW-1-2	X		X		X
PMW-1-3	X*		X*		X*
PMW-1-4	X		X		X
PMW-2-1					
PMW-2-2	X		X		X
PMW-2-3	X		X		X
PMW-2-4	X		X		X
PMW-3-1					
PMW-3-2	X		X		X
PMW-3-3					
PMW-3-4					
PMW-1S					
PMW-1I					
PMW-1D					
PMW-2I					
PMW-2D					
PMW-3I					
PMW-3D					
PMW-4D					
BMW-1I					
BMW-1D	X		X		X
MB-30					
Subtotal	**0**	**0**	**11**	**0**	**11**
Bottleware					
*Field Duplicate**	0	0	1	0	1
Trip Blanks	0	0	0	0	0
Sample Total*	0	0	12	0	12
Bottleware Total	**0**	**0**	**36**	**0**	**12**

*Collect field duplicate at PMW-1-3.

**Includes QA/QC samples.

-Collect field parameters (temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purgi

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Performance Sampling Event #4
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**	**Census (qPCR)**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**Microbial Insights**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM	No Preservative
Bottleware	Three 40 mL	Three 40 mL	Two 40 mL	One 15 mL conical	One 50 mL conical	One 1000 mL
Monitoring Wells						
PMW-0-1	X		X	X	X	
PMW-0-2	X		X	X	X	
PMW-0-3	X		X	X	X	X
PMW-0-4	X	X	X	X	X	X
PMW-1-1	X		X	X	X	
PMW-1-2	X		X	X	X	
PMW-1-3	X	X	X	X	X	X
PMW-1-4	X	X	X	X	X	
PMW-2-1	X		X	X	X	
PMW-2-2	X		X	X	X	
PMW-2-3	X		X	X	X	
PMW-2-4	X	X	X	X	X	
PMW-3-1	X		X	X	X	
PMW-3-2	X		X	X	X	
PMW-3-3	X		X	X	X	
PMW-3-4	X	X	X	X	X	
PMW-1S	X		X	X	X	
PMW-1I	X		X	X	X	
PMW-1D	X*	X*	X*	X*	X*	
PMW-2I	X		X	X	X	
PMW-2D	X		X	X	X	
PMW-3I	X		X	X	X	
PMW-3D	X		X	X	X	
PMW-4D	X	X	X	X	X	
BMW-1I	X		X	X	X	
BMW-1D	X*	X	X*	X*	X*	X
MB-30	X		X	X	X	
Subtotal	**27**	**8**	**27**	**27**	**27**	**4**
Bottleware						
*Field Duplicate**	2	1	2	2	2	0
Trip Blanks	3	0	0	0	0	0
Sample Total*	32	9	29	29	29	4
Bottleware Total	**96**	**27**	**58**	**29**	**29**	**4**

*Collect field duplicates at PMW-1D and BMW-1D

**Includes QA/QC samples.

-Collect field parameters (Temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purging.

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Performance Sampling Event #5
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Two 40 mL	One 15 mL conical	One 50 mL conical
Monitoring Wells					
PMW-0-1	X		X	X	X
PMW-0-2	X		X	X	X
PMW-0-3	X		X	X	X
PMW-0-4	X	X	X	X	X
PMW-1-1	X		X	X	X
PMW-1-2	X		X	X	X
PMW-1-3	X	X	X	X	X
PMW-1-4	X	X	X	X	X
PMW-2-1	X		X	X	X
PMW-2-2	X		X	X	X
PMW-2-3	X		X	X	X
PMW-2-4	X	X	X	X	X
PMW-3-1	X		X	X	X
PMW-3-2	X		X	X	X
PMW-3-3	X		X	X	X
PMW-3-4	X	X	X	X	X
PMW-1S	X		X	X	X
PMW-1I	X		X	X	X
PMW-1D	X*	X*	X*	X*	X*
PMW-2I	X		X	X	X
PMW-2D	X		X	X	X
PMW-3I	X		X	X	X
PMW-3D	X		X	X	X
PMW-4D	X	X	X	X	X
BMW-1I	X		X	X	X
BMW-1D	X*	X	X*	X*	X*
MB-30	X		X	X	X
Subtotal	**27**	**8**	**27**	**27**	**27**
Bottleware					
*Field Duplicate**	2	1	2	2	2
Trip Blanks	3	0	0	0	0
Sample Total*	32	9	29	29	29
Bottleware Total	**96**	**27**	**58**	**29**	**29**

*Collect field duplicates at PMW-1D and BMW-1D

**Includes QA/QC samples.

-Collect field parameters (Temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purging.

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Performance Sampling Event #6
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**	**Census (qPCR)**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**Microbial Insights**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM	No Preservative
Bottleware	Three 40 mL	Three 40 mL	Two 40 mL	One 15 mL conical	One 50 mL conical	One 1000 mL
Monitoring Wells						
PMW-0-1	X		X	X	X	
PMW-0-2	X		X	X	X	
PMW-0-3	X		X	X	X	X
PMW-0-4	X	X	X	X	X	X
PMW-1-1	X		X	X	X	
PMW-1-2	X		X	X	X	
PMW-1-3	X	X	X	X	X	X
PMW-1-4	X	X	X	X	X	
PMW-2-1	X		X	X	X	
PMW-2-2	X		X	X	X	
PMW-2-3	X		X	X	X	
PMW-2-4	X	X	X	X	X	
PMW-3-1	X		X	X	X	
PMW-3-2	X		X	X	X	
PMW-3-3	X		X	X	X	
PMW-3-4	X	X	X	X	X	
PMW-1S	X		X	X	X	
PMW-1I	X		X	X	X	
PMW-1D	X*	X*	X*	X*	X*	
PMW-2I	X		X	X	X	
PMW-2D	X		X	X	X	
PMW-3I	X		X	X	X	
PMW-3D	X		X	X	X	
PMW-4D	X	X	X	X	X	
BMW-1I	X		X	X	X	
BMW-1D	X*	X	X*	X*	X*	X
MB-30	X		X	X	X	
Subtotal	**27**	**8**	**27**	**27**	**27**	**4**
Bottleware						
*Field Duplicate**	2	1	2	2	2	0
Trip Blanks	3	0	0	0	0	0
Sample Total**	32	9	29	29	29	4
Bottleware Total	**96**	**27**	**58**	**29**	**29**	**4**

*Collect field duplicates at PMW-1D and BMW-1D

**Includes QA/QC samples.

-Collect field parameters (Temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes during purging.

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).

Post Treament Sampling Event
Sample Location and Analysis
Cometabolic Treatment of a Large, Dilute cVOC Plume
ESTCP Project No. 500814
Former Myrtle Beach Air Force Base, South Carolina

Analyte	**VOCs**	**1,4-Dioxane**	**MEEP**	**Anions**	**Total Ammonia**
Laboratory	**APTIM**	**APTIM**	**APTIM**	**APTIM**	**APTIM**
Method / Preservative	EPA 8260 / HCl	EPA 8260/SIM APTIM	EPA 3810m / HCl	EPA 300 / No Preservative	Hach Method 8155 APTIM
Bottleware	Three 40 mL	Three 40 mL	Two 40 mL	One 15 mL conical	One 50 mL conical
Monitoring Wells					
PMW-0-1	X		X	X	X
PMW-0-2	X		X	X	X
PMW-0-3	X		X	X	X
PMW-0-4	X	X	X	X	X
PMW-1-1	X		X	X	X
PMW-1-2	X		X	X	X
PMW-1-3	X	X	X	X	X
PMW-1-4	X	X	X	X	X
PMW-2-1	X		X	X	X
PMW-2-2	X		X	X	X
PMW-2-3	X		X	X	X
PMW-2-4	X	X	X	X	X
PMW-3-1	X		X	X	X
PMW-3-2	X		X	X	X
PMW-3-3	X		X	X	X
PMW-3-4	X	X	X	X	X
PMW-1S	X		X	X	X
PMW-1I	X		X	X	X
PMW-1D	X*	X*	X*	X*	X*
PMW-2I	X		X	X	X
PMW-2D	X		X	X	X
PMW-3I	X		X	X	X
PMW-3D	X		X	X	X
PMW-4D	X	X	X	X	X
BMW-1I	X		X	X	X
BMW-1D	X*	X	X*	X*	X*
MB-30	X		X	X	X
Subtotal	**27**	**8**	**27**	**27**	**27**
Bottleware					
*Field Duplicate**	2	1	2	2	2
Trip Blanks	3	0	0	0	0
Sample Total*	32	9	29	29	29
Bottleware Total	**96**	**27**	**58**	**29**	**29**

*Collect field duplicates at PMW-1D and BMW-1D

**Includes QA/QC samples.

-Collect field parameters (Temperature, pH, specific conductivity, ORP, DO), water levels, and purge rates every 5 minutes

-Remove tubing from flow-through cell to collect analytical samples (do not collect samples through the cell).