Spring 5-4-2021

SILVER BOW CREEK/BUTTE AREA NPL SITE BUTTE PRIORITY SOILS OPERABLE UNIT

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May 4, 2021

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RE: Butte Treatment Lagoons (BTL) Stress Test Quality Assurance Project Plan (QAPP)

Agency Representatives:

I am writing you on behalf of Atlantic Richfield Company to submit Draft Final *Butte Treatment Lagoons (BTL) Stress Test Quality Assurance Project Plan (QAPP)* for your review and approval. Activities described within this QAPP are anticipated to be completed from July through November 2021. Because of the pressing schedule, Atlantic Richfield is respectfully requesting expedited review and comments prior to June 4, 2021.

Once your comments have been received and incorporated, Atlantic Richfield will submit a Final revision of the BTL Stress Test QAPP for approval. The report may be downloaded at the following link:
https://pioneertechnicalservices.sharepoint.com/:f:/s/submitted/EklbQgSyxRREsOYjCKnsu20BuzvpvTO1BNUe4C-fTmURPQ

If you have any questions or comments, please call me at (406) 723-1834.

Sincerely,

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SILVER BOW CREEK/BUTTE AREA NPL SITE
BUTTE PRIORITY SOILS OPERABLE UNIT

2021

Draft Final

Butte Treatment Lagoons Stress Test
Quality Assurance Project Plan (QAPP)

Atlantic Richfield Company

Revision 0: May 2021

SILVER BOW CREEK/BUTTE AREA NPL SITE
BUTTE PRIORITY SOILS OPERABLE UNIT

2021

Draft Final

Butte Treatment Lagoons Stress Test Quality Assurance Project Plan (QAPP)

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Revision 0: May 2021

APPROVAL PAGE

Silver Bow Creek/Butte Area NPL Site
Butte Treatment Lagoons
Stress Test Quality Assurance Project Plan

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Approved: ____ Date: ______________
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Approved: ____ Date: ________________
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Plan is effective on date of approval.

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Acronym	Definition	Acronym	Definition
1-Cells	A1, B1, and C1 Cells	**MPTP**	Montana Pole and Treating Plant
%R	Percent Recovery	**NAVD**	North American Vertical Datum
Atlantic Richfield	Atlantic Richfield Company	**NFG**	National Functional Guidelines
bgs	below ground surface	**NPL**	National Priorities List
BPSOU	Butte Priority Soils Operable Unit	**NST**	Northside Tailings
BRW	Butte Reduction Works	**NTU**	Nephelometric Turbidity Units
BTC	Blacktail Creek	**OM&M**	Operation, Maintenance, and Monitoring
BTL	Butte Treatment Lagoons	**OPM**	Operations Project Manager
CAR	Corrective Action Report	**ORP**	Oxidation-Reduction Potential
CD	Consent Decree	**PARCCS**	Precision, Accuracy, Representativeness, Comparability, Completeness, and Sensitivity
CFRSSI	Clark Fork River Superfund Site Investigations	**PCB**	Polychlorinated Biphenyl
CLP	Contract Laboratory Program	**PCP**	Pentachlorophenol
CPM	Contractor Project Manager	**PDF**	Portable Document Format
CRQL	Contract Required Quantitation Limit	**PDI ER**	Pre-Design Investigation Evaluation Report
DE	Diggings East	**PDS**	Post Digestion Spike
DEQ	Department of Environmental Quality	**pH**	Potential Hydrogen
DI	Deionized	**PHREEQC**	pH REdox EQuilibrium Version C
DO	Dissolved Oxygen	**Pioneer**	Pioneer Technical Services, Inc.
DQA	Data Quality Assessment	**PVC**	Polyvinyl Chloride
DQO	Data Quality Objectives	**QA**	Quality Assurance
EDD	Electronic Data Deliverable	**QAM**	Quality Assurance Manager
EPA	U.S. Environmental Protection Agency	**QAO**	Quality Assurance Officer
FRE	Further Remedial Elements	**QAPP**	Quality Assurance Project Plan
FRESOW	Further Remedial Elements Statement of Work	**QC**	Quality Control
gpm	Gallons per minute	**RA**	Remedial Action
HCC	Hydraulic Control Channel	**RPD**	Relative Percent Difference
HDPE	High Density Polyethylene	**S2AVEM**	Stage 2A Validation Electronic and Manual
hp	horsepower	**SBC**	Silver Bow Creek
HSSE	Health, Safety, Security, and Environment	**SC**	Specific Conductance
LAO	Lower Area One	**SOP**	Standard Operating Procedure
LCS	Laboratory Control Sample	**SOW**	Statement of Work
LCSD	Laboratory Control Sample Duplicate	**SSHASP**	Site-Specific Health and Safety Plan
LM	Liability Manager	**TPH**	Total Petroleum Hydrocarbon
LMS	Laboratory Matrix Spike	**VFD**	Variable Frequency Drive
LMSD	Laboratory Matrix Spike Duplicate	**WCP**	West Camp Pump
MB	Method Blank		

1.0 INTRODUCTION

This Quality Assurance Project Plan (QAPP) provides guidance for evaluating the upper treatment capacity limit of the Butte Treatment Lagoons (BTL) system, located at Lower Area One (LAO) in the Butte Priority Soils Operable Unit (BPSOU) (Figure 1). The evaluation incorporates a pilot study performed to assess the high flow physical and chemical treatment capacity of the BTL system. The study, hereafter referred to as the Stress Test, will use sustained incremental increase of influent flow rates to determine the upper limit of effective treatment at BTL.

This QAPP follows guidance from the U.S. Environmental Protection Agency (EPA) *Uniform Federal Policy for Quality Assurance Project Plans: Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs* (EPA, 2005) and includes the following four basic element groups:

- Project management and objectives.
- Measurement and data acquisition.
- Assessment and oversight.
- Data review.

This QAPP includes all necessary protocols and procedures to perform the Stress Test, operational information about the BTL, and the types of actions and data collection necessary to ensure meaningful test results.

1.1 Purpose of the Stress Test

Additional treatment capacity may be needed to accommodate construction dewatering flow, when necessary, and increased influent flow following implementation of the Further Remedial Elements (FREs) under the BPSOU Consent Decree (CD) (EPA, 2020) (referred to herein as the BPSOU CD). Forward projections of increased water treatment demand within BPSOU create the need to determine the upper treatment capacity of BTL. The purpose of the Stress Test is to determine if the existing BTL has sufficient treatment capacity to accommodate additional influent flow created by implementation of these FREs.

The Stress Test is anticipated to determine the upper limits of the physical throughput capacity of the BTL system and identify any chemical limitations with treatment at higher flows. The physical capacity of BTL is bound by the physical BTL infrastructure (e.g., pipes, pumps, conveyance structures, etc.), while the chemical limitations are dependent on the upper treatment limit (i.e., a function of the influent flow rate and chemistry, chemical dosing rate, residence time, etc.) at which BTL is no longer able to meet discharge compliance goals (Table 1).

Physical and chemical processes interact dynamically within the spatial and temporal boundaries of the BTL system. Key features of the BTL system are shown on Figure 2. Determination of the physical and chemical thresholds at BTL will help inform planning, design, and construction of remedial actions (RAs) as outlined in the Further Remedial Elements Statement of Work

(FRESOW) (BPSOU CD), in addition to assisting in the determination if expansion, duplication, or modification of BTL will be required. To support the Stress Test investigation, this document includes the following:

1. Site Background (Section 2.0).
2. Data Quality Objectives (DQOs) (Section 3.0).
3. Stress Test Design and Sampling Process (Section 4.0).
4. Measurement Performance Criteria for Data (Section 7.0).
5. Measurement Data Acquisition (Section 8.0).
6. Data Management (Section 9.0).
7. Data Validation and Usability (Section 10.0).
8. Assessment and Oversight (Section 11.0).
9. Project Organization and Responsibilities (Section 12.0).
10. Health and Safety (Section 13.0).
11. Schedule (Section 14.0).
12. Reporting (Section 15.0).

This document references Pioneer Technical Services, Inc. (Pioneer) Standard Operating Procedures (SOPs) for specific activities that outline procedures to safely complete tasks. All referenced SOPs are in Appendix A.

1.2 Stress Test Objectives

The objectives of the Stress Test include identifying the physical and chemical limitations of the BTL system. During recent routine operations, BTL treats flow at 60%-70% of the design maximum treatment capacity. Treatment at this level of capacity allows operational flexibility to accommodate wet weather events, unplanned maintenance, and other disruptions, as well as maximizing the efficiency and lifespan of system components. However, the theoretical design treatment capacity has never been attained for a sustained period, and the functional treatment capacity of the system remains undetermined. The Stress Test will increase and sustain influent flow sufficiently to evaluate and characterize these physical and chemical limitations.

The Stress Test will use augmented influent flow pumped from a variety of groundwater sources, representative of construction dewatering and hydraulic containment sources, to increase the total treatment flow rate to near or exceeding theoretical design capacity. By increasing flow with proper monitoring and shutoff thresholds, the Stress Test aims to safely evaluate the functional treatment capacity of the BTL system, and therefore meet the objective of determining the primary physical and chemical limitations. Identification of chemical treatment limits by increasing flow will necessitate a temporary variance to discharge standards (Table 1).

Using data collected prior to and during the Stress Test, a PHREEQC (pH REdox EQuilibrium Version C) geochemical model of the system will be developed that will lend insight into the governing chemical processes at higher flows and given chemistry (USGS, 2013). Successful evaluation will give BPSOU project managers an improved understanding of the ability of BTL to handle increases in flow and chemistry relating to the RAs and improved knowledge of system resilience.

2.0 BACKGROUND

Implementation of the remedial elements described in the FRESOW (BPSOU CD) will result in additional groundwater capture requiring treatment and discharge. The maximum design flow rate of BTL is currently estimated at 1,800 gallons per minute (gpm) (Atlantic Richfield, 2019); with additional influent from groundwater capture, there is a risk of exceeding the current theoretical design treatment capacity of the BTL system (Atlantic Richfield, 2020a). The Stress Test will be performed to assess the effectiveness of the existing BTL system to treat water at flows chemically representative of groundwater capture additions at or above estimated flow capacity.

Although BTL influent rates vary seasonally, and wet weather flows sometimes require increased throughput, the BTL treatment effectiveness has not been assessed at sustained high flows, nor with water chemically representative of future flows resulting from FRE implementation. Sustained increase of influent flow may indicate a physical limitation or chemical treatment 'breakthrough' in the system that has not previously been observed. The following sections address the key elements of the problem and introduce the need for additional sampling and analysis to determine functional treatment thresholds.

2.1 Site History

The BTL system was initiated as a pilot project in 1998 to determine the ability of a passive chemical addition treatment system to treat groundwater in BPSOU. In subsequent years, the BTL system has been greatly expanded, upgraded, and improved into its current form. As of this writing, the BTL successfully treats and discharges more than 600 million gallons of water per year, averaging a discharge of around 1,100 gpm. A general timeline of major changes and upgrades to the BTL system is below:

- **1998:** Completion of LAO Expedited Removal Action.
- **1998:** Commencement of West Camp operations.
- **2001:** BTL pilot system upgrades (including expansion of lagoons and construction of the Chemical Addition System).
- **2002:** Installation of lime silo.
- **2004:** Installation of BPSOU subdrain.
- **2005:** BTL upgraded and expanded.
- **2005:** Subdrain pumps begin discharging to the hydraulic control channel (HCC).
- **2006:** Missoula Gulch bypass completed.
- **2008:** Subdrain dry vault and pump station building constructed.

- **2012:** BTL Phase I Construction Upgrades (West Camp Pump [WCP] station, influent pump station and influent lines, Automatic Sampling Building, lagoon cells, and outlet structures).
- **2014:** BTL Phase II Construction Upgrades (access roads and parking, site utilities, Chemical Addition System Building, Operations Building, lime feed system, sludge management, instrumentation, and controls).
- **2015:** Subdrain pump station upgrade (alternate discharge line to BTL, new pig launcher and piping manifold vault, new piping extension to BRW-00 Pond).

The portions of the groundwater capture and treatment system that are the focus of the Stress Test are limited to the BTL site. Capture and conveyance system infrastructure capacity, such as that of the BPSOU subdrain and WCP station, are not included in this capacity evaluation. The BTL treats captured groundwater from four major sources:

1. WCP system.
2. BPSOU subdrain.
3. Missoula Gulch base flow.
4. Butte Reduction Works (BRW), LAO, and HCC capture.

In addition to these primary sources, BTL receives intermittent stormwater runoff from the West Side drainage basin and the Butte-Silver Bow Metro Sewer Plant, and locally captured and recycled groundwater flow within the BTL footprint (D-cells) (Figure 2). In anticipation of potentially greater treatment needs, as work begins under the FRESOW (BPSOU CD), this QAPP focuses on the physical and chemical treatment processes occurring from the BPSOU subdrain discharge into the HCC, all the way through the system to the lagoon cell effluent discharge lines. The QAPP identifies data collection to observe any changes in the physical and chemical treatment processes as increasing influent flows through the treatment system.

2.2 Implications of Remedy Work

The RA work prescribed in the FRESOW (BPSOU CD) will include construction dewatering and the installation of additional hydraulic control infrastructure. Increases in flow requiring treatment will be most significant in the short-term (construction dewatering) but will be sustained in the long-term (installation of hydraulic controls). As a result, determination of the upper level of treatment efficacy will be critical to determining the water balance during and after the implementation of remedy work. The 2020 BPSOU Capture and Treatment System Performance Evaluation Scoping Document ('Scoping Document'; Atlantic Richfield, 2020a) provides a detailed overview of the current groundwater remedy and outlines the anticipated sources and magnitude of future capture flows.

2.3 Problem Definition

The problem definition has been developed based on the problem background and on the requirements of the BPSOU CD. For the Stress Test evaluation, the problem definition requires:

1. Identification of limiting physical factors in increasing BTL treatment flows to and above the theoretical design capacity.
2. Chemical interpretation of BTL treatment efficacy at increasing flows in comparison to normal operating conditions.

Evaluation of the existing BTL system will be required to determine the capacity for increased treatment flows to meet the upcoming RA demand. Appendix B.1 of the Scoping Document (Atlantic Richfield, 2020a) gives a general description of physical treatment capacity and potential barriers to flow increases. Limiting physical components of the BTL system will be identified during the Stress Test. The Stress Test will also provide chemical data on treatment efficacy during an extended period of high flow.

2.3.1 Temporary Variance Standards

The Stress Test will involve pushing the BTL system to the point where treatment may fail to produce effluent in compliance with current discharge standards. Discharge from BTL during routine operations exhibits a high compliance rate with the discharge standard set forth in the BPSOU CD, also listed in Table 1. During the Stress Test, it is expected that treatment efficacy will decrease during sustained high flow conditions. Additional monitoring will be established to help the project team quickly estimate the predicted discharge quality, as the treatment residence time will decrease during sustained high flow conditions. The system is expected to return to routine conditions within approximately two weeks of the conclusion of the test.

Prior to entering the Compliance Determination Period, temporary variance standards are proposed for interim adoption during the Stress Test pilot and subsequent construction dewatering activities until RA components have been completed and demonstrated as operational. The proposed discharge standards are protective of the receiving water, and robust monitoring will ensure the Stress Test discharge does not cause adverse effects to the receiving water. Table 1 lists the proposed temporary variance standards for the criteria analytes listed in the BPSOU CD (note the compliance point at BTL will not change from its current position during routine operations). The proposed temporary variance standards are based on the national chronic aquatic standards (as dissolved fraction) (Table 1). The use of existing federal aquatic life criteria as the proposed variance standards ensures that protectiveness of human health and the aquatic environment of Silver Bow Creek (SBC) will be maintained while allowing the Stress Test to identify limitations of the chemical and physical treatment capacity of BTL.

3.0 DATA QUALITY OBJECTIVES

The DQOs are statements that define the type, quality, quantity, purpose, and use of data to be collected. EPA developed a seven-step process for establishing DQOs to help ensure that data collected during a field sampling program will be adequate to support reliable site-specific decision making or estimation, whichever is appropriate.

The DQOs were developed for the Stress Test according to the EPA *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA, 2006) under the decision-making process. For the Stress Test, DQOs follow the guidance for estimation type fieldwork and are listed in Table 3.

4.0 STRESS TEST DESIGN AND SAMPLING PROCESS

During the Stress Test, BTL influent flow rates and chemistry will be systematically evaluated using augmented flow, and the system response will be observed. The Stress Test design and sampling process includes a variety of work related to this process, including establishing BTL routine conditions; sampling, pumping, and transmitting augmented groundwater influent; and sampling and observation to evaluate the geochemical conditions of the treatment system. Data collected before and during the Stress Test will be used to develop and calibrate a PHREEQC geochemical model of the system with multiple water sources, lime treatment, and potential hydrogen (pH) adjustment to aid in understanding treatment kinetics in relation to variable water chemistry and greater flow volumes (USGS, 2013). Further description of the model and model objectives are in Section 6.1.4 and Table 3.

This Stress Test QAPP includes all requisite information to plan and perform the work to meet the project goals. The Stress Test design components include installing two additional pumping wells, approximately 8,000 feet of temporary water conveyance line, and all necessary mechanical equipment to transfer the pumped water (pumps, valves, meters, tanks, etc.) (Figure 3). Water quality sampling will primarily occur at BTL after the augmented influent has been safely and successfully transmitted to the HCC and subsequently to the influent pumps at Lagoon Cell D4. Typical treatment flow paths through BTL from the Chemical Addition Systems (CAS) building to the effluent are shown on Figure 4.

This section details the fieldwork to be completed, including pre-test activities, pumping and conveyance systems, sampling procedures and locations, and other activities. Table 4 provides an overview of the data to be collected and the proposed monitoring for the Stress Test. Figure 3 shows the locations of influent groundwater sources. Because of unforeseen circumstances, changes to the Stress Test work activities proposed herein might be necessary, and additional activities or modifications may be performed by the Field Team Leader and Contractor Project Manager (CPM) in coordination with the Contractor Quality Assurance Officer (QAO).

4.1 Sampling Process and Test Design

Sampling and data collection for the Stress Test is designed to ensure that the data will be of sufficient quality and quantity to answer the principal study questions in Step 2 of the DQO process (Section 3.0). The Stress Test data collection includes baseline sampling at BTL, sampling the pumping wells newly installed for the test, geochemical conditions sampling, and effluent compliance sampling. Data collection locations and frequency are outlined in Table 4.

The Stress Test is designed to provide additional representative flow to BTL and observe the system response through a variety of sampling and monitoring methods. During periods of routine flow, BTL operational procedures already employ a robust monitoring system, daily sampling, and routine maintenance activities (Atlantic Richfield, 2019). These activities will continue to provide critical operational data during the Stress Test, with the addition of sampling and monitoring specific to the Stress Test to meet the DQOs.

The Stress Test will involve increases in influent flow and related changes to influent chemistry in a stepwise fashion. Each step will be maintained until the BTL system approaches ‘steady-state’ conditions, and evaluated for chemical and physical stability, prior to increasing flow for the next step. Intermediate sampling points will provide data on changing conditions in the treatment cells, and the test may be paused, modified, or terminated if copper concentrations indicate chemical breakthrough (Table 5).

The threshold for steady-state conditions for the purposes of the Stress Test are defined as the point at which daily field pH and field copper concentrations in treatment cell samples are within plus or minus (±) 10% for 3 consecutive days (Step 5 of the DQO process, Table 3). Operators will collect and compile measurements and data into a daily field sheet to be sent to the Field Team Leader, CPM, and QAO for review and confirmation of trends.

If steady-state thresholds are not met after the anticipated stabilization time, each step may be maintained for an additional week or as necessary to ensure treatment stabilization, depending on sampling results and the judgment of the Field Team Leader and CPM. If the steady-state condition threshold cannot be met during any step after 3 weeks, steady-state conditions and the decision to proceed to the next flow step will be determined by the Field Team Leader, CPM, and QAO using a combination of residence time stability, evaluation of water quality trends, and insight from the operations team.

The test will consist of three steps, using a combination of augmented flow from the pumping wells.

Step 1. The first step will increase BTL influent flow by approximately 300 gpm. It is anticipated that the steady-state condition threshold will be reached during Step 1 in approximately 2 weeks. Flow will be maintained by pumping from 2 BRW pumping wells and the Blacktail Creek (BTC) pumping well. The BRW and BTC wells were selected in Step 1 to represent the future additional flows from the potential BRW and BTC hydraulic controls. Also, the BTC pumping test may be conducted during Step 1 (a forthcoming QAPP will detail these proposed investigation activities). If the BTC pumping test is conducted during Step 1, a 3-day pause between Step 1 and Step 2 will be necessary to allow for the recovery portion of the BTC pumping test. During this 3-day pause, the 2 BRW wells will continue pumping, unless shutting down pumping is deemed necessary by the Field Team Leader, CPM, and QAO for maintenance or monitoring purposes.

Step 2. The second step is anticipated to increase flow by approximately 460 gpm above the routine flow. It is anticipated that steady-state condition threshold will be reached in approximately two weeks, following the same steady-state and chemical breakthrough decision making as Step 1 (Table 3). The flow for Step 2 is expected to be produced from two pumping wells at BRW and two pumping wells at Diggings East (DE) (the BTC pumping well will be turned off for Step 2). The DE and BRW wells were selected in Step 2 to represent future additional flows from the BRW and BTC hydraulic controls where the BTC hydraulic control is implemented in an area closer to the DE site (Figure 3).

Step 3. The third step will increase influent flow up to approximately 810 gpm above the routine flow using a combination of BRW, BTC, Northside Tailings (NST), DE, and WCP system sources. It is anticipated that the steady-state condition threshold will be reached in approximately 10 days. If the BTL system continues to maintain the physical integrity and chemical treatment benchmarks listed in Table 3 and Table 5, Step 3 will continue for up to 2 weeks. The final configuration of pumping well flows, step magnitudes, and step lengths may change due to production uncertainty in proposed wells to be installed. The final configuration of the Stress Test steps will be determined by the CPM and Contractor QAO, in conjunction with BTL operators and the Field Team Leader. Any changes in the configuration of the Stress Test steps will be communicated to Agency oversight.

The CPM, Field Team Leader, and QAO may decide to cease pumping at any time during the stress test pumping activities. Indications of treatment breakthrough from analytical sample data, field sampling, operational data, and professional judgment may all inform the decision to suspend Stress Test activities. Intermediate sampling data will provide early warning of increasing contaminant concentrations (Section 6.1.4), and rush opportunity sampling will confirm these results (Table 5 and Table 6).

4.2 Pre-Test Activities

Several work items will be completed prior to the start of the Stress Test. Two additional pumping wells will be installed: BRW-PW-02 and DE-PW-02 (Figure 3). Well installation details are discussed in Section 4.3. Additionally, a third pumping well used to convey Stress Test influent will be installed pursuant to a forthcoming BTC Remediation and Contaminated Groundwater Hydraulic Control Site Pumping Test QAPP. In addition to the installation of the two pumping wells, the Stress Test will require installation of temporary electric power service connections along with development field forms, flow diagrams, and preliminary operational checklists.

4.2.1 Property Access

Any area where work will be performed for the Stress Test that Atlantic Richfield Company (Atlantic Richfield) does not own will be subject to an access agreement, including the locations where augmented influent water will be pumped from and conveyed across (Figure 3). Any monitoring wells used to monitor water levels during the Stress Test that are located on adjacent private properties will use existing access agreements or the design team will obtain updated or new access agreements as necessary; there are no such access agreements anticipated at the time of this writing. Copies of any requisite access agreements will be placed in the field binder to have on hand during the pumping test activities.

4.2.2 Utility Locates

A plot plan for the locations of the additional pumping wells installed prior to the Stress Test will be generated by Pioneer based on records provided by the utility owners. All utility locations shown will be subject to the accuracy of the location methods and records employed by the owners. Final locations of subsurface utilities for the work area will be completed by the proper authorities prior to any ground disturbance activities.

4.2.3 Temporary Power Service Connections

Electric line power service connections will be installed to provide electric power to pumps, variable frequency drives (VFDs), meters, and monitoring equipment at the augmented influent source locations for the duration of the Stress Test and may be left in place for use in further RA activity at the discretion of the CPM (refer to Section 12.0). Installation of temporary line power service to the pumping locations in lieu of diesel generator power will decrease disturbance to the community, improve safety, reduce local carbon dioxide emissions, and increase reliability during the tests.

The anticipated location and alignment of the power service connection to be installed for the BRW pumping wells is shown on Figure 5. NorthWestern Energy will install a transformer and meter at this service location, and overhead service will be extended to each pumping well location. At each location, a disconnect will be installed upstream of the VFD.

The temporary power connection location and alignment to the existing and proposed pumping wells at NST and DE are shown on Figure 6. From an existing transformer near the NST pumping well, a service will be installed and approximately 300 feet of underground conduit will be trenched to the well at a minimum depth of 24 inches, following all required specifications (NFPA, 2017). NorthWestern Energy will install a transformer near the DE pumping wells, and a service and underground conduit will be installed to the DE wells. At each pumping well location, a disconnect will be installed upstream of the VFD. Proposed power service to the BTC pumping well will consist of an overhead power line from the main service line along George Street; the preliminary alignment and features are shown on Figure 7.

Conceptual line drawings detailing the anticipated installation of electric line power at the locations on Figure 5, Figure 6, and Figure 7 are included in Appendix B. The preliminary line drawings are not intended for construction, and the final details of electric line service connections may change as determined by the CPM and Contractor QAO.

4.2.4 Preliminary Action Items at BTL

Preventative maintenance and cleaning will be performed at BTL prior to the start of the Stress Test to ensure system components are functioning as designed prior to treatment flow increases. Routine Operation Maintenance and Monitoring (OM&M) activities performed at BTL are summarized in the BTL Groundwater Treatment System Routine OM&M Plan (Routine OM&M Plan) (Atlantic Richfield, 2019). Work items to be performed prior to the start of the Stress Test include the following:

- **Dredging Cell D4:** Cell D4 be cleaned out prior to the start of the test to reduce the amount of fine material that may be resuspended during high flow conditions.
- **Cleaning sluice box, mixing tank, and screw conveyor:** Lime delivery components are subject to scale and sediment buildup, and will be cleaned prior to the beginning of the test to optimize conveyance capacity.
- **Maintaining carbon dioxide delivery system:** The carbon dioxide (CO_2) delivery system typically operates in the winter months when ice prevents atmospheric exchange from naturally lowering system pH prior to discharge. During periods of increased flow, shortened residence time may necessitate carbon dioxide delivery in the effluent line to lower pH. The carbon dioxide tanks will be filled and the system will be primed and operational at the start of the test. Vendors will be notified of the possibility of requiring additional carbon dioxide delivery.
- **Upgrading flow meters:** Electromagnetic flow meters installed in both the BTL influent and effluent flow lines will be replaced, reprogrammed, and calibrated prior to the start of the test to ensure accurate treatment flow measurements.
- **Cleaning effluent line and camera inspection:** Combined effluent lines from cells B3 and C3, as well as the independent line from cell A3, are scheduled to be jetted and inspected with a camera to verify their integrity prior to the Stress Test.
- **Preparation of supplemental discharge line:** At high flow, the combined 14-inch gravity flow effluent line may not transmit sufficient flow to prevent increases in lagoon cell elevations. Two Dri-Prime CD100M diesel pumps (or equivalent), 1 primary and 1 backup, 4-inch effluent line, and supplemental carbon dioxide diffuser will be installed to pump treated water from the A3 outlet area to SBC as needed to maintain lagoon cell elevations. The 4-inch supplemental discharge line will be coupled with a 400-pound GL Series XL-50 Taylor Wharton CO2 Storage Tank, a Kentak D-4100 EVA-0140 supply hose, and a ½ inch Sweetwater bubble diffuser (or equivalent setup) to maintain discharge pH. A sampling port will be installed, and supplemental discharge pH will be monitored after carbon dioxide addition, prior to entering SBC, as specified in Table 6.

The above pre-test work items at BTL are mentioned here for relevance; these work items at BTL will be performed under BTL routine operation and maintenance activities where feasible and are subject to the guidance of work plans independent of this QAPP.

4.2.5 West Camp Additional Capacity

The WCP Station (WCP-1, Figure 2) maintains groundwater levels approximately 11 feet below the critical water level. Prior to the start of the Stress Test, the WCP pumps will be temporarily shut off and the groundwater will be allowed to rise (recent observations typically show about 0.5 feet per day increase in groundwater elevation when pumping ceases). The system will then be used for additional flow during Step 3 of the Stress Test by increasing the pump flow rate to draw down the groundwater storage created prior to the test. Groundwater level monitoring during maintenance shutoffs and start-ups at WCP-1 indicate that an additional 80-100 gpm will be available from storage in the WCP aquifer during the Stress Test using this method. During the first 2 phases of the test, the pump rate will be kept at routine rates, and then the pumping rate will be increased to begin lowering the WCP level at a faster rate until the routine operational elevation is met (providing increased flow to BTL for the final stage of the test).

4.3 Pumping Well Installation

Two additional pumping wells are proposed to meet the DQOs for the Stress Test. The approximate locations of the proposed pumping wells are shown on Figure 3. At the DE site, the proposed pumping well will be installed near DE-PZ-10A, approximately 100 feet northwest of the existing well DE-PW-01; a new drill pad will be installed at this location for use during the construction. At the pad location, a 12-inch layer of base course will be installed in two 6-inch lifts and compacted to a minimum of 95% dry density. The surface will exhibit approximately 2% grade for drainage, and the pad will be approximately 5,000 square feet in area (40 feet radius). A typical cross section of the pad installation is shown on Figure 8. The final thickness and size of the drill pad may be modified by the CPM and QAO as site conditions necessitate.

At the BRW Site, an additional pumping well is proposed between existing pumping well BRW-PW-01A and BRW-PW-01B. This location will require preparation prior to drilling. The selected location (Figure 3) will not require any grading but will require the installation and compaction of base course material to be suitable for the drilling equipment. Suitable base course material is available on site. Maximum 8-inch loose lifts will be installed as necessary to achieve a minimum total compacted section thickness of 12 inches at a minimum of 95% dry density. The surface will exhibit an approximate 2% grade for drainage, and the pad will be approximately 5,000 square feet in area (40-foot radius). A typical cross section of the pad installation is shown on Figure 8.

The additional pumping well locations will be drilled using the mud rotary method and will have an 8-inch finished screen diameter. The polymer mud rotary drilling method was selected over cable tool, sonic, or air rotary due to the following advantages:

- Drilling creates an open hole that facilitates construction of the well.
- The fluid-filled hole stabilizes the borehole and controls formation heave by maintaining a positive borehole pressure; heaving sands have been encountered in the RA areas.
- Drilling proceeds quickly with no steel casing to weld or handle.
- Drilling does not introduce air into the formation, which can cause oxidation and precipitation of dissolved contaminants.
- The polymer mud will break down over time or can be accelerated with the use of additives during well development.

Equipment, materials, supplies, drilling mud information, and well development are discussed in the sections below.

Prior to final selection of the additional pumping well locations, a preliminary borehole will be drilled and abandoned in each of the proposed pumping well locations using the Geoprobe®

7822DT unit. The preliminary boreholes will be drilled to confirm subsurface conditions prior to the installation of the large diameter pumping well to aid in the completion of the pumping well and selection of an appropriate screen interval. Pioneer will follow SOPs Geoprobe-01-10, SOP-GW-02, SOP-GW-03, SOP-GW-10C, and SOP-GW-11 through SOP-GW-15 to install the temporary boreholes (Appendix A). The final configuration and location of the pumping wells may be modified by the Field Team Leader in consultation with the CPM, and/or Contractor QAO based on field observations.

4.3.1 Equipment, Materials, and Supplies

Equipment, materials, and supplies used to install the pumping wells will include, but may not be limited to, the following:

- Mud rotary rig, drill rods, and nominal 12-inch drill bit.
- A 12-inch steel surface casing.
- Mud pan to mix, store, and receive drilling mud.
- Potable water for mud mixing.
- Polymer mud additives.
- Stainless steel continuous wrap Vee-wire 8-inch well screen (slot size and length to be determined), with a 5-foot, 0-wrap screen sump.
- Polyvinyl chloride (PVC), solid 8-inch well casing with threaded adapter or similar for attaching well screen.
- Bentonite: 3/8-inch chips for annular well seal.
- Surge block/water jetting tool for developing well.
- Additive to break down the polymer drilling mud viscosity if necessary.
- Trash pump and/or vacuum truck.
- Wastewater haul truck/vacuum trucks.

4.3.2 Drilling Mud

The drilling mud will be mixed using potable water and a polymer (organic or synthetic, e.g., Matex Hole Control or equivalent). The polymer drilling mud was selected because it will break down and not plug the aquifer material like a bentonite-based drilling mud. The polymer-based drilling mud will provide the viscosity and gel strength to effectively remove cuttings and create a filter cake on the borehole wall for stabilization.

To facilitate drilling mud returns at the surface, a steel surface casing will be installed to a depth of approximately 5 feet, depending on the drill rig used. The driller will install a mud pan around the surface casing to hold and receive the return mud. Cuttings will drop out in the pan as the mud flows back toward the far end of the pan where the pump intake is located.

Once drilling is complete and the well is constructed, additives will be pumped into the column of drilling mud in the well to break down the polymer-based drilling mud before development begins. The mud will then be pumped from the well and mud pan into a vacuum or water truck for disposal at the BTL drying beds. Drilling mud selection and well development details may be modified by the Field Team Leader with approval from the CPM and Contractor QAO.

4.3.3 Screen and Casing

The pumping wells will be constructed using a 15-to-20 foot long stainless Vee-wire wrapped 8-inch diameter screen and solid 8-inch PVC well riser pipe (Figure 9). The slot size selected for the screen will be determined based on the lithology logged as part of the test well drilled using the Geoprobe unit (see Section 4.3). A 5-foot piece of 0-wrap screen will be installed on the bottom of the well string to create a sump for fines to accumulate for removal during development and to house the submersible pump during pumping for the Stress Test. A formation packer will be installed approximately 3 feet above the well screen to isolate the screen from the well seal above. Bentonite will be added above the formation packer to provide a well seal. The 8-inch PVC well riser pipe will be set to project out of the ground with a stick-up of approximately 2 feet. A 12-inch diameter locking steel protective casing will be installed around the 8-inch PVC well casing to safeguard the well. The final configuration and installation details of the screen and casing at each well may be subject to change by the CPM in consultation with the Contractor QAO and drilling contractor.

4.4 Additional Pumping Well Development

Pumping well development is necessary to ensure good hydraulic connection between the well and aquifer. The development process removes the finer-grained material in the screen zone, increasing the hydraulic conductivity in the aquifer material around the screen. Development of the pumping wells will include mechanical surging and pumping. No air development will occur to minimize the addition of oxygen into the aquifer and/or the coprecipitation of metals within the screened area.

Following drilling mud removal, the wells will be developed using a surge block within the solid casing portion of the well above the screen. After a period of gentle surging, the surge block will be removed from the well and a drop pipe installed to the bottom of the well. The fine material on the bottom of the well sump will be vacuumed or pumped out using a vacuum truck or trash pump. The process will be repeated as necessary with increasing surge block intensity until the well is properly developed. The well is considered developed when 3 consecutive readings for turbidity are below 5 Nephelometric Turbidity Units (NTUs) or are within 10% of each other and the water quality parameters are stable, or the well has been developed for 4 hours.

If a good hydraulic connection is not established with surging and pumping, other methods may be considered by the Field Team Leader in consultation with the CPM and/or Contractor QAO. This may include, but is not limited to, the following methods:

1. Over-pumping. This activity will use a trash pump, the pump used for the Stress Test, or other appropriate means, as deemed appropriate by the Field Team Leader in consultation with the CPM and/or Contractor QAO.
2. Water jetting. Water used for jetting may be pumped from the well and allowed to settle to minimize reintroduction of suspended particulates. Tap water will not be used.

During well development, the water level in the installed wells will be measured during pumping episodes to qualitatively determine the approximate amount of drawdown for an estimated pumping rate. This information will be used to approximate the initial pumping rate for the step-drawdown test (Section 5.2).

The well development approach may be modified, or additional steps added by the Field Team Leader in consultation with the CPM and/or Contractor QAO as conditions change in the field.

4.5 Piezometer Installation

Additional piezometers are proposed, pending access approval, for the 'early detection' monitoring network. The approximate locations of the proposed pumping wells are shown in Appendix D. Piezometers will be installed as best suits the field conditions.

All piezometers will be installed in general accordance with the SOP-GW-11 included in Appendix A. Specific details for the piezometer construction are provided on Figure 10. The Geoprobe unit will be used to install the piezometers. The procedures may change based on field conditions and equipment availability. Equipment, materials, and supplies used to install the piezometer will include, but are not limited to, the following:

- 1.5 inch by 5- or 10-foot Schedule 40 PVC (flush-threaded).
- One 1.5-inch by 5-foot Schedule 40 PVC pre-packed screen 0.010 slot (flush-threaded).
- One 1.5-inch PVC bottom cap.
- One 1.5-inch slip cap.
- Measuring tape.
- Water level probe.
- Metal tag with the identification.

The following procedures will be performed at each new piezometer location. Construction details are provided on Figure 10.

- Install screen interval: Once the target depth is reached, the well screen interval will be installed in the shallowest conductive unit as determined by the Field Team Leader and CPM in consultation with the Contractor QAO.
- Backfill over drillings: The team will backfill any over-drilled boring with hydrated bentonite chips or bentonite pellets to a depth of 2 feet or greater below the expected total

depth of the well, and transition to building filter pack (10-20 Mesh Colorado Silica Sand). This will help ensure that bentonite does not swell into the screened zone.

Alternatively, field personnel may elect to backfill the original borehole with bentonite, drill an adjacent borehole to the desired bottom depth of the piezometer, and install the piezometer in this second borehole.

For the Screen and Riser:

- Each piezometer will consist of 5 feet of 1.5-inch nominal diameter schedule 40 flush-threaded PVC well screen with a slot size of 0.010 inches, with 1.5-inch nominal diameter schedule 40 flush-threaded PVC blank casing extending to approximately 2.5 feet to 3 feet above the ground surface or finished as a flush-mount at locations where an aboveground surface finish is not possible (e.g., access roads, etc.).
- Install an appropriately sized schedule 40 slip-fit cap on top of the PVC blank casing before installing the filter pack and other components described below.

For the Filter Pack:

- Install the filter pack to at least 2 feet above the top of the screen.
- Install the annular seal of hydrated bentonite chips from the top of the filter pack to 6 to 12 inches below ground surface (bgs). For shallower completions of piezometers, the thickness of the seal and/or filter pack above the piezometer screen may be reduced by field personnel, as necessary.

For the Casing:

- Install a 4-to-6 inch by 5-foot steel surface casing from approximately 2.5 feet bgs to approximately 2.5 feet above ground surface.
- If the location is anticipated to be subject to frost-heave, such as in the western portion of the site, install a longer steel surface casing that extends below the frost line.
- In areas susceptible to flooding, the protective casing should extend high enough to be above flood level (OhioEPA, 2008).
- In high traffic areas, install 3 bollards around the piezometer.
- Install 10-20 mesh Colorado Silica Sand from 6 inches bgs to approximately 2 inches below the top of the 1.5-inch diameter PVC.
- Mark a measuring point on the north side of the inner casing using a permanent marker.
- Install a concrete pad around the surface casing.
- Provide a locking steel cap for each piezometer.
- Write the piezometer name, depth, and installation data on the underside of the locking steel cap.

Pioneer will prepare a piezometer completion log for the location and, at a minimum, it will contain the following:

- Time and date installed.
- Borehole, casing, and screen diameters.
- Bottom cap length.
- Boring depth (plus or minus 0.1 foot) in relation to the ground surface.
- Well depth (plus or minus 0.1 foot) in relation to the ground and final measuring point.
- Lithology logs.
- Casing materials.
- Screen size, length, and depth to top and bottom of screen from ground surface.
- Filter pack material, size, and thickness in relation to the ground surface.
- Seal thickness and depth below ground in relation to the ground surface.
- Depth to groundwater at time of completion, in relation to the ground and final measuring point.
- Survey-grade X and Y coordinates and elevations for the measuring point (marked on the north side of the PVC), top of protective casing, and ground surface.

All drilling equipment and accessories will be decontaminated at the completion of the piezometer installation.

4.5.1 Development

The piezometers will be developed following the general procedures detailed in SOP-GW-12 in Appendix A. The piezometer will be considered developed when 3 consecutive readings for turbidity are below 5 NTUs or are within 10% of each other and the water quality parameters are stable, or the piezometer has been developed for 4 hours. The water quality parameters are considered stable when 3 consecutive readings are as follows:

- Temperature range is no more than plus or minus 1 degrees Celsius (°C).
- pH varies by no more than 0.1 pH units.
- Specific Conductance (SC) readings are within 3% of the average.

Development water will be transported to a holding tank and sampled for petroleum compounds prior to management/disposal. The need for management/disposal options, if necessary, will be determined based on the laboratory results.

5.0 PUMPING SYSTEM

To reduce or eliminate the deficit between routine BTL summer flow volumes and the theoretical design maximum flow, a combination of existing and proposed pumping wells in BPSOU will provide representative groundwater influent. When possible, flow will be pumped from locations within or near required hydraulic control and anticipated future construction dewatering, to provide representative chemistry and volume. The existing and proposed augmented influent pumping wells are shown on Figure 3.

Flow for each of the Stress Test steps (Section 4.1) will be pumped from the wells using a Grundfos 7.5 horsepower (hp) stainless steel or equivalent submersible pump with dedicated controls, valves, and discharge lines. Where possible, pumps will discharge groundwater directly to an appropriately sized discharge line for transmission to BTL. Three wells (two installed and one proposed) will be used to pump groundwater from the BRW area and transmit that groundwater across SBC to the HCC, from which it flows to D4 and the influent pump station.

Three wells (two installed and one proposed) will pump water from the DE/NST area. Pumped groundwater from this area will be transmitted to the BPSOU subdrain pump station vault and transferred to BTL via the existing BPSOU subdrain pump station discharge lines. Additionally, one proposed pumping well (to be installed for the BTC pumping test) will transmit groundwater from the BTC area to the BPSOU subdrain vault. Increased flows to the subdrain vault will be transmitted to the HCC using the existing temporary Godwin Diesel CD150 and/or 300HH electric submersible pumps (electric pump as backup). Increased flows from WCP (Section 4.2.5) will be transmitted to BTL using the in-place infrastructure. Operations and equipment product specification sheets for proposed temporary infrastructure and field equipment, where offered, are included for reference in Appendix E.

5.1.1 Submersible Pumps and Controls

Submersible pumps will be installed in the pumping wells according to the specific procedures and methods required by the manufacturer. The pumps used for the pumping test are anticipated to range in size from 5 hp to 10 hp. The final make, model, and style of submersible pumps used for the Stress Test will be determined by the CPM and Contractor QAO with information received during the Step-Drawdown evaluation.

Each pump will connect to electric line power as previously described via a dedicated VFD (Phase Technologies 2XD207 or equivalent). Each VFD will allow operator adjustment of the pump motor speed to control the flow rate and will be connected to a single submersible level transmitter (Mercoid Bird Cage 0 to 15.0 pounds per square inch or equivalent), preventing dry run conditions. If it is determined there will be excessive head loss in the proposed discharge lines due to static head conditions and/or discharge line friction losses, the submersible pump may discharge to an intermediate holding tank with separate booster pump to ultimately convey flow to the required destination. The final configuration of pump drives, control, valving, and power delivery will be determined by the Field Team Leader and CPM in consultation with the Contractor QAO.

5.1.2 Water Conveyance

Water conveyance piping will be sized for the anticipated flow from each of the groundwater sources. Typically, the discharge pipe is expected to consist of a minimum of 4-inch diameter Duraline PolyPipe butt fusion welded high density polyethylene (HDPE), Yelomine Certa-Lok PVC, or equivalent. Where there is a complete pathway to surface water (100 feet either side of upper SBC or SBC crossings, where possible), conveyance lines will be placed within a second pipe (8 inch Duraline PolyPipe butt fusion welded HDPE or equivalent) for additional spill prevention dual containment. Discharge piping will be installed by the contractor using best practices and according to the final details prescribed by the CPM and Contractor QAO.

5.2 Step-Drawdown Tests

A one-day, step-drawdown test will be conducted at each of the two proposed additional pumping wells to determine an effective pumping rate from each location for the duration of the Stress Test. The *steps* referenced in this section are solely for determination of sustainable pumping rates and are unrelated to the Stress Test flow steps mentioned in Section 4.1. The step-drawdown tests may be performed at any time after well development and pump installation and prior to the beginning of the Stress Test. For the already installed pumping wells, and the proposed well at BTC, step-drawdown tests have already been performed or will be performed according to another QAPP or work plan.

The pumping rate during the Stress Test must maximize production flow while not decreasing the water level in the pumping well below the intake of the pump. The latter will disrupt the flow to BTL and may result in pump cavitation. Data collected during each step-drawdown test will be evaluated with the Walton (1987), Kruseman and de Ridder (1994), or equivalent methodology used in AQTESOLV analysis software to determine a sustainable pumping rate and size the pump for the Stress Test.

A step-drawdown test consists of pumping a well at three or more different pumping rates for an equivalent duration (approximately one hour for each step). It is not required that the steps be conducted sequentially (i.e., a pause to change pumps or equipment is acceptable) nor that each step be conducted on the same day, but it is helpful if each step is conducted for a similar duration. For the step-drawdown test, the intent is to conduct the test sequentially starting at the lowest pumping rate and increasing the rate with each step followed by the recovery. The first step of the step-drawdown test will be determined from the drawdown and pumping rates measured during well development (Section 4.4), and additional pumping steps may be necessary.

After each step of the step-drawdown test, if the drawdown in the pumping test well is at or near the level of the submersible pump, the pumping rate will be either decreased (after the water level is allowed to recover) or held at the same rate for the remainder of the step-drawdown test. If after pumping at two incremental steps the drawdown in the well is a fraction of the remaining water column height above the pump, the pumping rate will be increased for the third (and potentially fourth) step.

The number of steps, the pumping rates, and other aspects of the step-drawdown test may be modified by the Field Team Leader in consultation with the CPM and/or Contractor QAO, as necessary.

6.0 MONITORING AND SAMPLING

Water quality sampling and additional BTL system monitoring will be performed during the Stress Test to safely and effectively meet the DQOs listed in Table 3. The existing sampling and monitoring procedures followed during routine BTL operations (Atlantic Richfield, 2019) will result in the collection of extensive data useful for the Stress Test geochemical evaluation. Additional sampling during the Stress Test will include water quality samples collected from proposed additional pumping wells and at various locations in LAO to further aid in the geochemical analysis.

6.1.1 BTL System Monitoring and Physical Capacity Evaluation

During the Stress Test, BTL operators will continue daily monitoring and maintenance procedures in accordance with the OM&M Plan (Atlantic Richfield, 2019). Special attention will be given to relevant system alarms as discussed in the physical capacity assessment DQO in Table 3. During the test, lagoon cell elevations will remain within ‘normal’ design operating limits to prevent destabilization of internal structures and maintain groundwater capture gradients. The outlet structures act as level control devices for each lagoon cell, as stop logs can be added or removed to raise or lower cell elevation; an automated level alarm call-out system is in place to minimize the potential of water levels rising above the critical cell elevations (Atlantic Richfield, 2019). As flow increases through the system, maintaining lagoon elevations may require the use of a supplemental discharge system, as mentioned in Section 4.2.4 and shown on Figure 4. In the summer months, the A, B, and C lagoon series are typically operated in parallel (Figure 4). Treatment flow is expected to follow this pattern during the stress test, but treatment flow may be rerouted into a ‘series’ orientation by the operator, as necessary.

A list of all BTL system alarms and set points can be viewed in the *Final Systems Control Document for the Butte Treatment Lagoons (BTL) at Lower Area One (LAO) Treatment System* (Atlantic Richfield, 2014); a table of the relevant system alarms can be viewed in Appendix C.

6.1.2 Groundwater Monitoring

Influent pumping wells will be monitored for drawdown, and pumping rates will be controlled with the VFDs to maintain a consistent level of drawdown and prevent the water table from being drawn down to below the pump intake. Pumps and equipment will be checked daily by an operator to confirm the integrity of the pumping and metering equipment, and to record the totalized flow, date, time, and other pertinent field notes. Additional equipment to monitor and transmit pump and/or VFD functions may be added to reduce the frequency of field visits.

Pressure transducers will also be installed at a limited number of observation wells to meet the third DQO for groundwater source monitoring (Table 3). The groundwater observation network to be installed at BRW is shown on Figure 11. The groundwater observation network to be installed at NST/DE is shown on Figure 12. Additionally, groundwater monitoring will be established at select 'early detection' monitoring wells in the BRW area. As detailed in Section 6.1.5, the purpose of this additional early detection monitoring is to a) estimate concentrations of total petroleum hydrocarbon (TPH) in BRW pumping wells (see Appendix D1); and b) detect and limit the potential for migration of pentachlorophenol (PCP), polychlorinated biphenyl (PCB), and variants of dioxin (congeners) into BRW and/or LAO from the adjacent Montana Pole and Treating Plant (MPTP) NPL Site during the Stress Test (see Appendix D2). The final number and location of groundwater observation points is subject to change by the CPM and Contractor QAO.

6.1.3 Influent Rate Monitoring

A Fuji Electric FSV Ultrasonic Flow Meter, or equivalent, will be installed at each of the pumping wells and will record flow continuously on internal storage on each device. Flow data from each of the pumping well flow meters will be downloaded weekly, or at an appropriate interval determined by the Field Team Leader based on individual site conditions, to minimize the loss of data and totalized flow will be recorded more frequently for a backup in the case of data loss. Although proposed flow rates may vary slightly to maintain an acceptable groundwater level, each Stress Test step will maintain, as best achievable, a steady magnitude of flow for the duration of the step.

A level transducer will be installed at the staff gage locations in BRW-01W and an existing level transducer in BRW-00 will record water level fluctuations for the duration of the Stress Test (Table 4). When pumping commences at DE/NST during Step 2, flow rates will be recorded at the BPSOU vault as water is pumped through the BTL influent lines to the subdrain discharge in the HCC using the existing temporary Godwin Diesel CD150 and/or 300HH electric submersible pumps.

Recorded flows from each of the pumping wells will be communicated to BTL operations for comparison to measured flow rates in the BTL system. Flow measurements from the BPSOU subdrain and other routine influent sources to BTL are incorporated into the BTL Supervisory Control and Data Acquisition (SCADA) system, and subject to continuous monitoring and high/low flow alarms (Appendix C). Routine comparison of flows from the pumping wells, BPSOU subdrain pump station (at fixed and temporary pumps and discharge into the subdrain), and BTL influent will be performed during the test to ensure flow continuity in the conveyance network. All conveyance piping will be routinely inspected for potential leaks during use. The final configuration of pumps, meters, and conveyance infrastructure may be modified by the Field Team Leader and CPM, in consultation with the Contractor QAO.

6.1.4 Water Quality Sampling and Geochemical Assessment

Analytical water quality samples are collected from BTL influent and effluent locations on a routine basis (Table 4). The routine sampling intervals listed in Table 4 will provide sufficient resolution for determination of treatment efficacy during the Stress Test. Samples will be submitted for analysis according to the methods, analytes, and procedures shown in Table 5. The analyte list for the geochemical water quality samples collected during the Stress Test will be submitted for a different and larger set of analytes than is prescribed by routine BTL operations. The locations of water quality sampling stations within BTL/LAO and SBC are shown on Figure 13.

The PHREEQC model will use water quality data (analytical and field), site conditions, and several other parameters to estimate the geochemical conditions and kinetics of the system. Analytical water quality samples, and collected and observed field parameters (e.g., pH, oxidation-reduction potential [ORP], DO, etc.), will be used to calibrate and refine the model. Routine BTL operational data will provide a portion of the data for this analysis, but additional sampling prior to the test will help with the model calibration. Water quality data collected from the two additional influent pumping wells, the uppermost fully mixed location in the HCC (HCC-01A), and opportunity samples from the treatment cells, influent, and effluent locations will all aid in model calibration and sensitivity analysis.

The geochemical model will use collected data to determine the significance of metals and metalloids of concern in both aqueous and suspended sediment phases of treatment water. The model is primarily concerned with the mechanism of precipitation and co-precipitation of metal species and does not estimate floc development or adsorption rates of metals in suspension. Refinement of the model will identify controlling geochemistry and analytes (pH, redox potential, total carbon dioxide, arsenic, cadmium, copper, zinc, total dissolved solids, and possibly other constituents) during routine conditions and elevated flow conditions. Development of the routine conditions model prior to the test may be useful to predict contaminant concentrations resultant from increased flow and loadings of metal contaminants, allowing actions to be taken by operators to adjust lime treatment during the Stress Test. Data collected during the test at elevated flows may help with identification of mechanisms of possible chemical breakthrough and controlling chemical processes and inform future modifications or upgrades to mitigate chemical breakthrough. Objectives of the geochemical modeling are discussed in Table 3.

6.1.4.1 Field Parameters

Field parameters (pH, SC, temperature, DO, ORP, and turbidity) will be measured and recorded using a multi-probe field meter (Appendix A) with optical DO capabilities (a separate turbidity meter will be used to record that parameter). The BTL effluent pH data collected using a dedicated meter installed for continuous monitoring may also be used in the geochemical assessment. Field data will be an important tool for the Field Team Leader and Contractor QAO to assess changes in BTL chemistry during the Stress Test, and aid in the determination of steady-state conditions at each Stress Test flow step (Section 4.1; Table 3).

6.1.4.2 Water Quality Samples

Water quality samples will be collected from the two proposed pumping wells at the beginning and end of the Stress Test to aid in the calibration of the PHREEQC model. An additional water quality sample will be collected in the HCC prior to testing to help in model calibration (Figure 13). During the test, water quality sampling will be collected according to routine BTL procedures (Atlantic Richfield, 2019). Data collected under routine BTL procedures will proceed without change and may be referenced to aid in analysis. Water quality samples will be collected at the locations and intervals shown in Table 4, and analyzed according to the methods, analytes, and procedures listed in Table 5. Additional opportunity samples may be collected if deemed necessary by BTL operators, the Field Team Leader, and/or the CPM. Water quality samples will be collected according to relevant Pioneer SOPs (Appendix A).

6.1.4.3 Intermediate Field Sampling

During each step of the Stress Test, additional samples will be collected near the effluent of treatment lagoons A1, B1, C1, A2, B2, and C2 (Figure 13). During the Stress Test, the A, B, and C treatment pathways will be operating in parallel, each providing treatment to a portion of the overall influent flow (Figure 4). Flow will be measured at the influent to the A1, B1, and C1 cells, and at the outlet of the A2, A3, B3, and C3 cell outlet structures weekly during the test to help determine the residence time in each lagoon series. Changes to the flow pathways in BTL may be determined necessary by the operations team, who will notify the Field Team Leader and CPM.

Daily intermediate sampling at the A1, B1, C1, A2, B2, and C2 cells for field parameters and dissolved copper using a Hach DR 2800 field kit (or equivalent) will provide both an indicator of steady-state treatment conditions, and an 'early warning' indication of chemical treatment breakthrough (Table 3). Additional field kit sampling (e.g., for additional metal species) may be performed in these locations given increasing trends observed at the 1-Cell locations. If concentrations of field measured metals in the treatment water are determined to be increasing at the intermediate locations, the CPM and BTL operators will be notified, and the test could be paused or terminated if concentration thresholds are exceeded (Table 3). Field monitoring at the intermediate sampling locations will be continued for up to 14 days subsequent to the end of pumping activities to observe recovery and return to routine conditions (Table 5).

6.1.4.4 Surface Water Monitoring

During the Stress Test, water quality samples will be collected twice per week at the BTL effluent (EFS-07) at weekly at SBC locations SS-06G and SS-07 (Figure 13). Data collected at these locations during the test may be compared to the existing water quality dataset to monitor for any possible adverse effects to in-stream water quality resulting from the Stress Test activities. Data will be collected at these locations according to Table 4 and analyzed per Table 6. Additional opportunity samples may be collected if deemed necessary by the Field Team Leader in consultation with the CPM and QAO.

6.1.5 Other Water Quality Sampling

Analysis of groundwater pumped from BTL has resulted in detections of a number of hydrocarbon species concentrations below discharge criteria (Atlantic Richfield, 2020b). Effluent from the BRW pumping wells will be sampled and analyzed using a Hanby Field Test Kit to estimate concentrations of TPH. Any detection of TPH will be communicated to the BTL operators and CPM, and the Stress Test may be paused or terminated should there be detectable increases in hydrocarbon species, as per the hydrocarbon logic table (Appendix D1). Analytical grab samples may be collected to confirm detections using the field-testing kit and provide decision-making data for potential cessation of pumping. Sampling logic and procedures for field analysis of TPH in BRW production water are in Appendix D1.

To the southwest of the BRW remediation area site is the MPTP Superfund Site (MDHES, 1993). Among the contaminants of concern present in this location are PCP, PCB, and a number of dioxin species. Although the MPTP Site is downgradient/cross gradient of the BRW Site under normal conditions, extended pumping from the BRW pumping wells warrants careful monitoring of observation wells on the western edge of BRW, within the MPTP Site, and the adjacent NorthWestern Energy property due to resulting local drawdown of groundwater. Samples will be collected from selected 'early detection' monitoring wells using low-flow groundwater sampling methods (Appendix A) and analyzed for select analytes using a Modern Water RaPID Assay field kit, or equivalent, and analytical methods shown in Table 5. Sample collection details are outlined in Table 4 and further information is in Appendix D. Detection of water level changes or PCP concentrations per the logic in Appendix D.2 will be communicated to the BTL operators and CPM, and the Stress Test may be paused or terminated to prevent any adverse effects from possible contaminant migration.

6.1.6 Weather Monitoring

Weather will be recorded at the LAO/BTL weather station (Davis Instruments), which records temperature, pressure, wind speed, and precipitation. Additional weather information will be obtained through national and local weather services, as necessary.

During routine operations, BTL typically operates between 60%-70% of the maximum design capacity, and surges in flow caused by wet weather can be temporarily stored and metered into the system. When operating at or near the design capacity during the Stress Test, careful monitoring and anticipation of storm events will be required.

If a storm surge occurs during the test, the CPM and Field Team Leader, in conjunction with the BTL Lead Operator, may elect to reduce pumping rates at one or more pumping wells until the storm flow has been attenuated in the system. Daily field water quality parameters collected for the Stress Test will characterize system chemical changes due to the storm flow, and logbook notation of weather events and timing will aid in any assessment of water quality effects due to the storm event. Additional monitoring and data collection related to the storm event may be performed by the field team, as determined necessary by the Field Team Leader, CPM, and Contractor QAO.

6.2 Stress Test Duration

The Stress Test activities are anticipated to occur over a 20-week period from July through November of 2021, including pre-test activities and post-test breakdown of all field installation. A proposed project schedule is shown on Figure 14. The Stress Test may be terminated early according to the criteria described in the above sections and Table 3, or as determined by the BTL operators, Field Team Leader, and/or CPM.

6.3 Stress Test Data Analysis

Data from the Stress Test will be collected, stored, and validated according to the procedures in Section 6.0, Section 7.0, and Section 8.0. Analysis of the data will be conducted both during the Stress Test and afterwards. Both efforts will rely on accurate compilation of observational data, field data, and analytical chemistry data. Details regarding the assumptions, function, and calibration of the PHREEQC model will be included in an attachment to the subsequent report. Reporting requirements are in Section 15.0.

7.0 MEASUREMENT PERFORMANCE CRITERIA FOR DATA

Specific data validation processes ensure that analytical results are within acceptable limits. All information and data gathered during this investigation will be checked to ensure they are usable for their intended purposes. An evaluation of analytical control limits and of the precision, accuracy, representativeness, comparability, completeness, and sensitivity (PARCCS) parameters will be performed. If significant issues with the data are found, data results will be discussed with EPA and Montana Department of Environmental Quality (DEQ) project managers. EPA, in consultation with Montana DEQ, will then decide if the total study error could cause them to make an incorrect decision. Using this approach, the probability of making an incorrect decision (i.e., either a false negative or positive) based on the information collected is considered small.

The definitions of PARCCS are provided below along with the acceptance criteria for data collected and sensitivity parameters. They are also summarized in Table 8.

7.1 Precision

Precision is the amount of scatter or variance that occurs in repeated measurements of a particular analyte. Analytical precision is determined by the analyses of field and laboratory generated duplicates. An analytical duplicate is the preferred measure of analytical method precision. The overall random error component of precision is a function of sampling. Precision may be evaluated using duplicate analyses of laboratory prepared samples such as laboratory control sample (LCS)/LCS duplicate (LCSD) and laboratory matrix spike (LMS)/LMS duplicate (LMSD) samples. Relative Percent difference (RPD) is one way of reporting precision.

For this QAPP, precision will be determined by the analyses of field duplicates, laboratory (analytical) duplicates, and the evaluation of the RPD for these various paired measurements. For this study, acceptable precision will be an RPD of plus or minus 20% for aqueous samples when sample results are greater than 5 times the Contract Required Quantitation Limit (CRQL). If either of the sample results are less than 5 times the CRQL, the control limit used will be an absolute difference between sample results less than the CRQL. This precision requirement is derived from the Contract Laboratory Program (CLP) *National Functional Guidelines* (NFG) *for Inorganic Superfund Data Review* (EPA, 2017) and the *Clark Fork River Superfund Site Investigations Quality Assurance Project Plan (QAPP)* (CFRSSI QAPP) (ARCO, 1992a).

7.2 Accuracy

Accuracy is the ability of the analytical procedure to determine the actual or known quantity of a particular substance in a sample. The LCS and LMS are used to measure accuracy, and accuracy acceptance or rejection is based on the percent recovery (%R) of the LMS and LCS. Perfect recovery will be 100% (the analysis result is exactly the known concentration of the LMS or LCS). An acceptable accuracy range is 80.0% to 120% in aqueous samples. Accuracy requirements for this project are derived from the NFG (EPA, 2017) and the CFRSSI QAPP (ARCO, 1992a).

7.3 Representativeness

Data representativeness is defined as the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or environmental conditions. Representativeness is a qualitative parameter that is most concerned with the proper design of the sampling program. Representativeness will be achieved through judicious selection of sampling locations and methods. This QAPP has been designed to provide samples that are representative of the medium being sampled as well as a sufficient number of samples to meet the project DQOs and to satisfy the projects needed design elements.

The CPM, in consultation with the Groundwater Remedy Project Manager (GWR PM), will review the QAPP to ensure that it is designed to collect the data and information necessary to meet the purpose of the investigation. The review will consider the volume, variability, and intended use of the data to ensure proper sampling methods and adequate spatial distribution of samples.

After the data have been collected and analyzed, the CPM and GWR PM will review the data and qualitatively assess if the data adequately represent the site conditions and intended purpose of the investigation. Sample representativeness may also be evaluated using the RPDs for field duplicate sample results, if applicable.

7.4 Completeness

Completeness determines if enough valid data have been collected to meet the investigation needs. Completeness is assessed by comparing the number of valid sample results to the number of sample results planned for the investigation. The completeness target for this investigation is 95% or greater as designated in the CFRSSI QAPP (ARCO, 1992a).

7.5 Comparability

Data comparability is defined as the measure of the confidence with which one dataset can be compared to another. Comparability is a qualitative parameter but must be considered in the design of the sampling plan and selection of analytical methods, quality control (QC) protocols and data reporting requirements. Comparability will be ensured by analyzing samples obtained in accordance with this QAPP as well as the appropriate SOPs, which are comparable to the sampling methods used during previous investigations at the site. All data will be reported in units consistent with standard reporting procedures so that the results of the analyses can be compared with results from previous investigations. Groundwater elevations will be measured in feet (North American Vertical Datum [NAVD]88).

7.6 Sensitivity

Method sensitivity is related to the method detection limits. The method sensitivity or lower limit of detection depends on several factors, including the analyte of interest, the method used, the type of detector used, matrix effects, etc. Appropriate methods must be selected with sufficient method sensitivity to accomplish the project's goals.

Laboratory Analysis
The method sensitivity for laboratory analyses is determined as part of the laboratory's SOPs. A review of these detection limits will be conducted as part of the data validation process (Section 10.0).

Modern Water RaPID Assay PCP Screening Kit (PCP Screening Kit)
Field PCP screening will be conducted using Modern Water RaPID Assay PCP Screening Kit, or similar; dilution of some samples may be necessary prior to analysis. The method sensitivity or lower limit of detection for the PCP Screening Kit is 0.1 parts per billion for water samples. Also, the PCP Screening Kit does not differentiate between PCP and other organochlorines. Therefore, laboratory samples will also be collected and analyzed to evaluate observed concentrations of PCP, relative to concentrations of other organochlorines.

Hanby TPH Water Field Test Kit
Field hydrocarbon screening will be conducted using a Hanby TPH Water Field Test Kit, or similar; dilution of some samples may be necessary prior to analysis. The method sensitivity or lower limit of detection for the TPH Screening Kit is 0.05 to 0.1 parts per million for water samples, for PCBs and all other petroleum hydrocarbons, respectively.

Hach DR 2800 Multiparameter Handheld Colorimeter
Field screening for dissolved copper will be conducted using a Hach DR 2800 Multiparameter Handheld Colorimeter, or similar; dilution of some samples may be necessary prior to analysis. Range of detection for the Hach DR 2800 is 1 microgram per Liter (μg/L) to 8.0 milligrams per Liter (mg/L) for copper.

7.7 Special Training

All field personnel will have current certification for the *40-hour Occupational Safety and Health Administration Hazardous Waste Site and Emergency Response Training*. Current certification records are maintained at Pioneer headquarters at 1101 S. Montana Street in Butte, Montana.

In a project meeting held prior to fieldwork, all field personnel will review this QAPP. Field personnel will review sampling and monitoring procedures and requirements prior to field activities to ensure collecting and handling methods are completed according to the QAPP requirements. Field personnel will be trained in how to properly use field equipment and complete activities according to field data collection SOPs (Appendix A).

The Field Team Leader will conduct a review of the BPSOU and BTL Site Specific Health and Safety Plans (SSHASPs) with all field personnel prior to fieldwork to assess the site's specific hazards and the control measurements put in place to mitigate these hazards. The SSHASP review will cover all other safety aspects of the site including site personnel responsibilities and contact information, additional site-specific safety requirements and procedures, and the emergency response plan.

The Field Team Leader will be responsible for training field personnel on how to use field measurement instruments. The Field Team Leader will be experienced in the use of the equipment that will be used and responsible for training and overseeing the support staff.

One hard copy of the current approved version of this QAPP will be maintained for reference purposes in the field vehicle and/or field office. All field team personnel will have access to Adobe Portable Document Format (PDF) format files of all documents pertaining to sampling. All field team personnel will sign a page after receiving training indicating they understand the QAPP.

7.8 Documents and Records

All significant observations, measurements, data, and results will be clearly documented in field logbooks or on field data sheets according to the methods and procedures outlined in SOP-SA-05 Project Documentation (Appendix A).

8.0 MEASUREMENT DATA ACQUISITION

Acquisition of data resulting from the Stress Test activities includes various methods for field and laboratory sample collection. Detailed sample design is included in Section 4.0. Field data collection includes flow rates, water level measurements, field water quality parameters, and field analysis of PCP and TPH. Laboratory data include water quality samples collected from both groundwater and BTL treatment water. All data will be collected, recorded, stored, and revised according to the specific SOPs included in Appendix A, and will follow the management procedures discussed in Section 9.0.

8.1 Sampling Procedures

Procedures for the Stress Test sample process and design are outlined in Section 4.0 and include the collection of samples for laboratory analysis and field testing. Sampling for the Stress Test will primarily consist of routine sampling at BTL, which will be subject to the procedures and methods described in the BTL OM&M Plan (Atlantic Richfield, 2019). Additional sampling from the pumping well sources, at treatment locations within LAO, and within SBC will also be incorporated into the Stress Test. Procedures for sampling from groundwater wells prior to pumping are in SOP-GW-10C in Appendix A. During pumping, production water samples will be obtained through installation of a sample port. All other sampling of treatment water at BTL will be subject to the methods and procedures outlined in the BTL OM&M Plan and the BTL SSHASP.

8.2 Laboratory Methods

All water quality samples collected as part of the Stress Test investigation will be shipped to an Atlantic Richfield-approved laboratory(ies) for analyses as detailed in Table 7. The approved laboratory will have established protocols and quality assurance (QA) procedures that meet the regulations under the Laboratory Analysis Management Program.

8.3 Laboratory Quality Control Samples

Laboratory QC samples are introduced into the measurement process to evaluate laboratory performance and sample measurement bias. Laboratory QC samples can be prepared from environmental samples or generated from standard materials in the laboratory per the internal laboratory SOPs. The various laboratory QA sample information is listed below including the required type and frequency of laboratory QC checks associated with the metals analyses as defined by the CFRSSI QAPP (ARCO, 1992a).

Method Blank

The method blank (MB) samples will be prepared and analyzed for every 20 samples analyzed. The MB is laboratory deionized (DI) water that has gone through the applicable sample preparation and analysis procedure. Laboratory control limits on detection of an analyte in the blank are contained in the applicable laboratory method and SOP. Failure will trigger corrective action and the blanks will be re-analyzed. All samples affected will be footnoted with the appropriate flag to document contamination in the blank.

Laboratory Control Sample

The LCSs will be prepared and analyzed for every 20 samples analyzed. Control limits vary based on the laboratory method performed and are contained in the applicable laboratory method and SOP. Failure will trigger corrective action and the analysis should be terminated, the problem corrected, and the samples associated with that LCS re-analyzed. If re-analyses of the sample fails, the samples affected by the failing LCS elements need to be re-digested and re-analyzed.

Laboratory Matrix Spike/Matrix Spike Duplicate

The LMS and LMSD samples will be prepared and analyzed at different frequencies based on the laboratory method performed. The control limits also depend on the method used and are contained in the applicable laboratory method and SOP. If the %R for the LMS and LMSD falls outside the control limits, the results will be flagged as outside acceptance criteria along with the parent sample. If the RPD exceeds the acceptance criteria, the LMSD sample and associated parent sample will be flagged.

Laboratory Duplicate Sample

The laboratory duplicate samples (LDSs) will be prepared and analyzed for every 20 samples analyzed. An LCS and laboratory control sample duplicate (LCSD) pair or an MS and MSD sample pair may be used as the LDS. Control limits will vary based on the QC action used. Failure will trigger corrective action and a single re-analysis of the respective failing QC is allowed. If the re-analysis is outside the acceptance criteria, the analysis must be terminated, the problem corrected, the instrument recalibrated, and the calibration re-verified.

8.4 Field Duplicates

Field duplicates will be collected for the groundwater sampling. A field duplicate is an identical, second sample collected from the same location, in immediate succession of the primary sample, using identical techniques. The duplicate sample will have its own sample number. Duplicate samples will be sealed, handled, stored, shipped, and analyzed in the same manner as the primary sample. Both the primary sample and duplicate sample will be analyzed for identical chemical parameters by the laboratory. The analytical results of the primary and duplicate sample will be compared to determine sampling precision. Field duplicate samples will be collected at a frequency of 1 per 20 samples.

8.5 Field Blanks

Field blanks will be collected for the groundwater sampling effort. A field blank is a sample bottle containing DI or analyte-free water and appropriate preservatives and is prepared in the field. A sample bottle is randomly chosen from each lot of bottles received by the contract laboratory or supplier, and DI or analyte-free water is poured directly into the sample bottle while in the field and the bottle is preserved and shipped to the laboratory with the field samples. Field blanks must be prepared in the field; they help evaluate the potential for possible contamination from the sampling environment. The field blank will have its own unique sample number and will be recorded in the project logbook as a field blank or bottle blank. Field blanks will be prepared at a frequency of 1 per 20 samples.

8.6 Instrument/Equipment Testing, Inspection, Maintenance and Calibration

To ensure continual quality performance of all instruments and equipment, testing, inspection, and maintenance will be performed and recorded as described in this section. All field and laboratory equipment will be operated, maintained, calibrated, and standardized in accordance with all EPA and manufacturer's recommended procedures.

8.6.1 Field Equipment

Field equipment will be examined to verify that it is in proper operating order prior to its first use. Equipment, instruments, tools, gages, and other items requiring preventative maintenance will be serviced and/or calibrated in accordance with the manufacturer’s specified recommendations, as necessary. Field equipment will be cleaned (decontaminated) and safely stored between each use. Any routine maintenance recommended by the equipment manufacturer will also be performed and documented in field logbooks. Any equipment deficiencies or malfunctions during fieldwork will be recorded as appropriate in field logbooks.

Transducers
Transducers will be installed and programmed in accordance with SOP-GW-15 Continuous Groundwater Level Monitoring (Appendix A). Transducers will be maintained per manufacturer's specifications. Transducers will be site-dedicated to prevent potential cross contamination (e.g., BRW transducers will remain in BRW for the duration of the test) unless appropriate decontamination is completed. A transducer with an appropriate sensitivity level will be selected and deployed at the locations identified on Figure 11 and Figure 12.

Transducers will be installed and set to record at 15-minute intervals for a minimum of 3 days prior to beginning pumping to identify any existing background trends at monitoring locations. It is anticipated that transducers will be set to record on 1-minute intervals for the first day of each Stress Test step. After 1 day, the transducers may be downloaded and reprogrammed to record 1-hour data for the remainder of the step. Transducers will continue to record data for 7 days after the Stress Test is concluded, to determine total recovery and resulting trends. The final configuration and programming of transducers may be modified by the Field Team Leader, CPM and/or Contractor QAO.

The following data screening steps will be taken to ensure the water level measuring device data accurately represent field conditions.

- **Compensation:** Raw water level data will be barometrically compensated and, if necessary, manually adjusted in a Microsoft Excel spreadsheet to match acceptable manual water level measurements recorded in the field notes (manual measurements at deployment and each download). The compensated data will then be downloaded into the project database and plotted and analyzed for abnormalities (e.g., spikes, drops, inconsistencies, fluctuations, etc.).

- **Comparison:**
  - To justify atypical water level fluctuations, water level data will be compared to precipitation events at the BTL weather station (Section 6.1.6), flow data within the creek, and other relevant information.
  - Background trends in water levels will also be determined prior to beginning pumping.
  - Any discrepancies will be flagged in the data.

8.6.2 Laboratory Equipment

Instruments used by the approved laboratory(ies) will be maintained in accordance with the laboratory QA plan requirements and analytical method requirements. All analytical measurement instruments and equipment used by the laboratory(ies) will be controlled by a formal calibration and preventative maintenance program.

The laboratory(ies) will keep maintenance records and make them available for review, if requested. Laboratory(ies) preventative maintenance will include routine equipment inspection and calibration at the beginning of each day or each analytical batch, per the laboratory internal SOPs and method requirements.

8.7 Inspection/Acceptance of Supplies

All equipment used for the investigation will be checked to ensure that the condition of all components is satisfactory and free of defects that would affect performance. The types of equipment needed to complete sampling activities are described in the relevant field SOPs (Appendix A). Inspections of field supplies will be performed by the Field Team Leader and/or field team members. The personnel at each laboratory will be responsible for inspecting laboratory supplies in accordance with the laboratory QA program.

9.0 DATA MANAGEMENT

This section describes how the data for the project will be managed, including field and laboratory data. Data will be managed in in accordance with the BPSOU Data Management Plan (Atlantic Richfield, 2020c). Monitoring and automated data will be managed in the BTL data historian according to the BTL OM&M Plan (Atlantic Richfield, 2019). Atlantic Richfield will maintain the QAPP quality records. These records, in either electronic or hard copy form, may include the following:

- Project field sampling plan with any approved modifications, updates, and addenda.
- Project QAPP with any approved modifications, updates, addenda, and any approved corrective or preventative actions.
- Field documentation (including logbooks, data sheets, and photographs) in accordance with SOP-SA-05 Project Documentation (Appendix A).
- Chain of custody records (see SOP-SA-04 Chain of Custody Forms for Environmental Samples in Appendix A).
- Field forms.
- Laboratory documentation (results received from the laboratory will be documented in hard copy and in an electronic format).

Hard copy field and laboratory records will be maintained in the project's central data file, where original field and laboratory documents are filed chronologically for future reference. These records will also be scanned to produce electronic copies. The electronic versions of these records will be maintained on a central Microsoft SQL server system that is backed up regularly. The data will be stored on the SQL server and a Microsoft Access database will be set up to access the data, which can then be exported to Excel if desired for further graphing and interpretive analyses. Using a Microsoft-based software configuration is widely accepted with support from Microsoft and allows for easy data sharing with most hardware configurations.

All field and laboratory data and supporting documentation will be subject to appropriate review to ensure the accuracy and completeness of original data records prior to uploading into the project database. Field data that have been reviewed and approved in a hard copy format will be entered into an electronic system to be uploaded to the project database. Laboratory electronic data deliverables (EDDs) provided in Microsoft Excel format and correlating PDF Level 2 data packages (simplified format) will be reviewed as part of the internal data review process. Following these review steps, field and laboratory electronic data files will be imported to the project database.

Standardized data import formats and procedures will be used to upload both field and laboratory data into the electronic database. Standardized parameter names, numerical formats, and units of measure will be applied to the original information to facilitate comparability across all datasets and within the database. Using these standardized formats will allow for quick and easy querying to retrieve data as necessary. Data can be retrieved by exporting into an Excel file and, because the data will be formatted with parameter names, data can be easily made into a pivot table in Excel for easy data processing.

9.1 Sample Labeling and Identification

A sample number system will be used to uniquely identify the project site, the sample type, and the specific sample location. Additional samples will be collected under separate efforts (see Table 6, Group 5a and 5c); sample naming convention for these sample groups will be consistent with routine efforts, but their analytical data will be integrated for evaluation with samples collected for Stress Test efforts. The following is an example of the sample numbering system:

Sample Number: **ST-TW-A2-070421-T**

- Location/Event: *"ST"* – Stress test sampling event.
- Media: "*TW*" – Sampled from treatment water.
- Location: "*A2*" – Sample collected from treatment lagoon A2.
- Date: *"070421"* - sample collected on July 4, 2021.
- Duplicates: "T" – Duplicate or twin samples will be recorded on the field log or logbook.

Additional examples of sample labeling and identification for the Stress Test sample collection are listed in Table 8. A permanent marker will be used for labeling. All samples will be collected in the appropriate sample container, with preservative in place from the laboratory (if necessary). Samples will be collected, stored, handled, and shipped as described in Table 6 to the identified laboratory for analyses. A copy of the chain of custody record will accompany the samples during shipment and will serve as the laboratory request form. A chain of custody form will be completed that specifies the type of analysis requested for each individual sample. The original form will be maintained with the field notes and in the project records.

9.2 Field Documentation

Data and observations collected by the field team will be recorded in a field logbook. The field team will also photograph field activities. This section describes the procedures to organize and store this data.

9.2.1 Field Logbook

To provide a permanent record of all field activities, field personnel will document all activities in a bound field logbook (refer to field SOPs in Appendix A). This will include a description of site conditions during sampling activities. When field logbooks are used, each logbook will have a unique document control number, be bound, and have consecutively numbered pages. All entries will be in waterproof ink, and any mistakes will be lined out with a single line and initialed by the person making the correction. Whenever a sample is collected or a measurement is made, a detailed description of the sample location and any additional observations will be recorded. Individual field team members may be responsible for required documentation based on specific tasks assigned by the Field Team Leader or CPM.

All significant observations, measurements, relevant data, and results will be clearly documented in the data log or the field logbook. At a minimum, the following will be recorded:

- A description of the field task.
- Time and date fieldwork started.
- Location and description of the work area including sketches if possible, map references, and references to photographs collected.
- Names and titles of field personnel.
- Name, address, and phone number of any field contacts or site visitors (e.g., Agency representatives, auditors, etc.).
- Meteorological conditions at the beginning of fieldwork and any ensuing changes in the weather conditions.
- Details of the fieldwork performed and the field data sheets used.
- All field measurements made.
- Any field analysis results.
- Personnel and equipment decontamination procedures.
- Deviations from this QAPP or applicable field SOPs (Appendix A).

For the test boreholes at the pumping well locations the following entries will be made:

- Lithologic log of the test boring indicating material types, from and to depths, rock content, color, presence of water, etc.
- Depth intervals from the ground surface for each soil horizon and total depth of the test boring.
- Photograph or video of each test boring with a staff gage or tape measure for scale to document existing conditions. Include site name ID in photograph using a white board or note pad.
- Abnormal occurrences, deviations from this QAPP, or other relevant observations.

For any field sampling work the following entries will be made:

- Sample location and ID number.
- Sample type collected.
- Date and time of sample collection.
- Sample location descriptions and designations, and any notable features of the water sample (as applicable). Further sample information will be included with the laboratory results.

- Sampling method, particularly any deviations from the field SOPs (Appendix A).
- Sample preservation (if used).

9.2.2 Field Photographs/Videos

Photographs will be taken of sampling locations and field activities using a mobile device or digital camera. When practical, photographs should include a scale in the picture as well as a white board with relevant information (e.g., time, date, location, sample number, etc.). Additional photographs documenting site conditions will be taken, as necessary. Documentation of all photographs or videos taken during sampling activities will be recorded in the bound field logbook or appropriate field data sheets (refer to field SOPs in Appendix A), and will specifically include the following for each photograph taken:

- Time, date, and location.
- Photograph or video number from the camera or video recorder.
- The identity of the person taking the photograph/video.
- Direction that the photograph or video was taken and description of the subject photographed.

The digital files will be placed with the electronic project files with copies of supporting documentation from the bound field logbooks.

9.3 Sample Handling, Documentation, and Shipping

As applicable, samples will be either hand delivered or shipped via Federal Express (or other appropriate shipping facility) to the appropriate laboratory under strict EPA chain of custody procedures. Samples will be shipped in appropriate containers that will prevent detrimental effects to the sample.

Sample containers and holding times are listed in Table 6. All procedures will strictly follow appropriate protocols and field SOPs in Appendix A. Chain of custody records will be kept with the samples and custody seals will be placed on the sample storage containers (coolers).

9.3.1 Chain of Custody

The SOP for chain of custody (SOP-SA-04) is in Appendix A. Maintaining the integrity of the sample from collection through data reporting is critical to the sampling and analytical program. This process includes the ability to trace the possession and handling of samples from the time of collection through analysis and final disposition. This documentation of the sample's history is referred to as chain of custody. A sample is under an individual's custody if it is in that individual's physical possession, in view of the individual after taking possession, or secured by that individual so that no one can tamper with the sample.

The components of the field chain of custody (chain of custody form, labels, and custody seals) and laboratory chain of custody (chain of custody form, custody seals, and laboratory custody) are described in this section.

9.3.1.1 Chain of Custody Form

A chain of custody form will be completed and will accompany every sample. A standard form will be provided from each laboratory. The form will include the following information:

- Project code.
- Project name.
- Sampler's signature.
- Sample identification.
- Date sampled.
- Time sampled.
- Analysis requested.
- Remarks.
- Relinquishing signature, data, and time.
- Receiving signature, date, and time.

9.3.1.2 Custody Seals

Custody seals are used to detect unauthorized tampering with samples following sample collection up to the time of analysis. Custody seals will be applied to the shipping containers any time that the samples are not in the sampler's custody.

9.3.1.3 Laboratory Custody

Laboratory custody procedures will conform to procedures per the EPA CLP Statement of Work (SOW) for Inorganic Superfund Methods (EPA, 2016). These procedures include the following:

- Designation of sample custodian.
- Correct completion of the chain of custody form, recording of sample identification numbers, and documentation of sample condition upon receipt.
- Laboratory sample tracking and documentation procedures.
- Secure sample storage.

The samples will be delivered to the laboratory for analysis in a timely manner to ensure the requested analyses can be performed within the specified allowable holding times. The sample will be hand delivered or addressed to a person in the laboratory who is authorized to receive samples (laboratory sample custodian).

10.0 DATA VALIDATION AND USABILITY

This section addresses the final project checks conducted after the data collection phase of the project is completed to confirm that the data obtained meet the project objectives and to estimate the effect of any deviations on data usability for the express purposes of achieving the stated DQOs (Section 3.0). Based on a review of EPA guidance, Atlantic Richfield proposes Level 2 data validation. The analytical data collected will undergo Stage 2A Validation Electronic and Manual (S2AVEM) as defined in EPA *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use* (EPA, 2009) (Level 2 data validation).

10.1 Data Review

This section describes the review and verification process for field data and the internal laboratory data reduction process. The section also details laboratory data reporting requirements, which describe how results are conveyed to data users.

10.1.1 Field Data Review

Raw field data will be entered in field logbooks and/or field data sheets and the data will be reviewed for accuracy and completeness by the Field Team Leader before the records are considered final. The overall quality of the field data from any given sampling round will be further evaluated during the process of data reduction and reporting.

Field data reduction procedures will be minimal in scope compared to those implemented in the laboratory setting. Field data review will include verification that any QC checks and calibrations, if necessary, are recorded properly in the field logbooks and/or data sheets and that any necessary and appropriate corrective actions were implemented and recorded. Such data will be written into the field logbook and/or data sheets immediately after measurements are taken. If errors are made, results will be legibly crossed out, initialed, and dated by the field member, and corrected in a space adjacent to the original (erroneous) entry. Later, the Field Team Leader will proof the field logbooks and/or data sheets to determine whether any transcription errors have been made by the field crew. If transcription errors have been made, the Field Team Leader and field crew will address the errors to provide resolution.

If appropriate, field measurement data will be entered into electronic files for import to the project database. Data entries will be made from the reviewed field data sheets or logbooks, and all data entries will be reviewed for accuracy and completeness before the electronic file is provided to the database manager. Electronic files of field measurement data will be maintained as part of the project's quality records.

10.1.2 Laboratory Data Review

Internal laboratory data reduction procedures will be according to each laboratory's quality management plan. At a minimum, paper records will be maintained by the analysts to document sample identification number and the sample tag number with sample results and other details, such as the analytical method used (e.g., method SOP), name of analyst, the date of analysis, matrix sampled, reagent concentrations, instrument settings, and the raw data. These records will be signed and dated by the analyst. Secondary review of these records by laboratory personnel will take place prior to final data reporting to Atlantic Richfield. The laboratory will appropriately flag unacceptable data in the data package.

10.2 Data Verification

Data verification is the process for evaluating the completeness, correctness, and conformance / compliance of a specific dataset against the method, procedural, or contractual specifications.

10.2.1 Field Data Verification

The Level A/B review, as described in the CFRSSI Data Management/Data Validation (DM/DV) Plan (ARCO, 1992b), will be used in the verification process for field documentation related to samples collected for laboratory analysis.

The Level A criteria are:

- Sampling date.
- Sample team and/or leader.
- Physical description of sample location.
- Sample collection technique.
- Field preparation technique.
- Sample preservation technique.
- Sample shipping records.

The Level B criteria are:

- Field instrumentation methods and standardization complete.
- Sample containers preparations.
- Collection of field duplicates.
- Proper and decontaminated sampling equipment.
- Field custody documentation.
- Shipping custody documentation.
- Traceable sample designation number.
- Field notebook(s), custody records in secure repository.
- Complete field forms.

10.2.2 Laboratory Data Verification

The laboratory will prepare Level 2 data packages for transmittal of results and associated QC information to Atlantic Richfield or its designee within a standard turnaround time, unless otherwise required, with all the requested types of information in an organized, consistent, and readily reviewable format.

Each data package, as described above, will be accompanied by an EDD prepared by the laboratory. Additional laboratory QC data can be included in the EDD. The EDDs will be cross checked against corresponding data reports to confirm consistency in results reported in these two separate formats. This cross check will take place as part of the data verification process.

The data packages from the laboratory will contain the following minimum information:

- A narrative addressing any anomalies encountered during sample analysis, and a discussion of any exceedances in the laboratory QC sample results.
- Analytical method references.
- Definition of any data flags or qualifiers used.
- Chain of custody documentation signed and dated by the laboratory to indicate sample receipt.
- Method detection limits and reporting limits.
- Analytical results for each field sample.
- QC sample results (as applicable).

10.2.3 Verification and Validation Methods

The Level A/B Assessment checklists included in Appendix F are based on the CFRSSI DM/DV Plan guidance (ARCO, 1992b). Level 2 verification and validation checks include an evaluation of the following, as applicable for each analytical method:

- Completeness of laboratory data package.
- Requested analytical methods performed.
- Holding times.
- Preservation.
- Reported detection limits.
- Method blanks.
- LCS and LCSD.
- LMS samples and LMSD samples.
- Laboratory duplicate samples.

- Field blanks.
- Field duplicates.

Data qualifiers will follow those used in the NFG for Inorganic Superfund Methods Data Review (EPA, 2017). Data validation for each laboratory data package will be documented on the data validation checklists.

The data validator will be responsible for reviewing field documentation associated with sample collection, conducting the verification and validation of laboratory-produced data, and completing a data validation report, which will be reviewed by the CPM.

10.2.4 Reconciliation and User Requirements

The Data Quality Assessment (DQA) process described in the CFRSSI DM/DV Plan (ARCO, 1992b) and the Guidance for Data Quality Assessment EPA QA/G-9 (EPA, 2000) will be performed to determine whether project-specific DQOs have been satisfied. The DQA process consists of five steps that relate the quality of the results to the intended use of the data:

Step 1: Review DQOs and sampling design.
Step 2: Conduct preliminary data review.
Step 3: Select statistical test(s), as appropriate, to evaluate data quality.
Step 4: Verify assumptions.
Step 5: Draw conclusions about the quality of the data (data report will not include interpretation of results but will state conclusions regarding the quality of the results).

If, as a result of the DQA process, it is determined that data do not satisfy all DQOs, then corrective action(s) should be recommended. Corrective actions include, but are not limited to, revision of the DQOs based on the results of the investigation, or collection of more information or data. It may be determined that corrective actions are not required, or the decision process may continue with the existing data, with recognition of the limitations of the data.

The PARCCS data quality indicators (Section 7.0) will be used when conducting the DQA. If the PARCCS assessment satisfies the project DQOs, then usability of the data will follow the enforcement/screening/unusable data categories as described in the CFRSSI DM/DV (ARCO, 1992b):

1. Enforcement Quality (Unrestricted Use) Data

   Enforcement quality data may be used for all purposes under the Superfund program including the following: site characterization, health and safety, Environmental Evaluation/Cost Analysis, remedial investigation/feasibility study, alternatives evaluation, conformational purpose, risk assessment, and engineering design.

2. Screening Quality (Restricted Use) Data

   Potential uses of screening quality data, depending on their quality, include site characterization, determining the presence or absence of contaminants, developing or refining sampling and analysis techniques, determining relative concentrations, scoping and planning for future studies, engineering studies and engineering design, and monitoring during implementation of the response action.

3. Unusable Data

   These data are not usable for Superfund-related activities.

Data that meet the Level A and Level B criteria and are not qualified as estimated or rejected during the data validation process are assessed as enforcement quality data and can be used for all Superfund purposes and activities. Data that meet only the Level A criteria and are not rejected during the data validation process can be assessed as screening quality data. Screening quality data can be used only for certain activities, which include engineering studies and design. Data that do not meet the Level A and/or B criteria and/or are rejected during the data validation process are designated as unusable. The data are assigned one of the following qualifiers:

E = Enforcement quality. No qualifiers or U qualifier and meets Level A and B criteria.
S = Screening quality. J or UJ qualifier and/or meets only Level A criteria.
R = Unusable. R qualifier and/or does not meet Level A or B requirements.

Enforcement/Screening Designation Guide

	Meets Level A and B	Meets Level A	Does not meet Level A or B
No qualifier, A, or U	E	S	R
J, J+, J-, or UJ	S	S	R
R	R	R	R

11.0 ASSESSMENT AND OVERSIGHT

Assessment and oversight of data collection and reporting activities are designed to verify that sampling and analyses are performed in accordance with the procedures established in this QAPP. The audits of field and laboratory activities include two independent parts: internal and external audits. Internal audits will be performed by Atlantic Richfield, their contractor, or a contracted laboratory consultant, as necessary. External audits will be performed by EPA, as necessary. Performance and systems audits of field and laboratory data collection and reporting procedures are described in this section.

11.1 Corrective Action Procedures

Corrective action is the process of identifying, recommending, approving, and implementing measures to counter unacceptable procedures or out of QC performance, which can affect data quality. Corrective action can occur during field activities, laboratory analyses, and data assessment.

Non-conforming equipment, items, activities, conditions, and unusual incidents that could affect data quality and attainment of the project's quality objectives will be identified, controlled, and reported in a timely manner. For this QAPP, a nonconformance is defined as a malfunction, failure, deficiency, or deviation that renders the quality of an item unacceptable or indeterminate in meeting the project's quality objectives. Corrective actions implemented by field personnel will follow appropriate field SOPs, as necessary.

Corrective action in the laboratory may occur prior to, during, and after initial analyses. Several conditions such as broken sample containers, preservation or holding time issues, and potentially high concentration samples may be identified during sample log in or just prior to analyses. Corrective actions to address these conditions will be taken in consultation with the CPM and GWR PM and reported on a Corrective Action Report (CAR) form. If corrective action requests are not in complete accordance with approved project planning documents, EPA will be consulted and concurrence will be obtained before the change is implemented.

Completion of any corrective action should be evidenced by data once again falling within the project's performance criteria. If this is not the case, and an error in laboratory procedures or sample collection and handling procedures cannot be found, the results will be reviewed by the CPM, GWR PM and Field Team Leader to assess whether re-analysis or re-sampling is required.

All corrective actions taken by the laboratory will be documented in writing by the Laboratory Project Manager and reported to the Field Team Leader and CPM. If corrective action requests are not in complete accordance with approved project planning documents, EPA will be consulted and concurrence will be obtained before the change is implemented. All corrective action records will be included with the QAPP records.

11.2 Corrective Action During Data Assessment

During data assessment, the Contractor QAO could identify the need for corrective action. Potential types of corrective action include re-sampling by the field team, re-analyzing samples by the laboratory, or re-submitting Level 2 data packages with corrected clerical errors. The appropriate and feasible corrective actions are dependent on the ability to mobilize the field team and whether the data to be collected are necessary to meet the required QA objectives (e.g., the holding time for samples is not exceeded, etc.). If corrective action requests are not in complete accordance with approved project planning documents, EPA will be consulted and concurrence will be obtained before the change is implemented. Corrective actions of this type will be documented by the Contractor QAO on a CAR and will be included in any subsequent reports.

11.3 Quality Assurance Reporting

After the investigation is complete, Atlantic Richfield's contractor will prepare a pre-design investigation evaluation report (PDI ER) (Section 15.0) summarizing the sampling activities. The report will describe specific field activities performed and the physical characteristics of the study area. The report will include field documentation, documentation of field QC procedures, and the results of all field and laboratory audits. The report will also contain a discussion of the DQA. These discussions will contain the results of any associated field and laboratory audits, information generated on achieving specific DQOs, and a summary of any corrective actions that were implemented and their immediate results on the project. A detailed listing of any deviations from the approved QAPP will also be provided with an explanation for each deviation and a description of the effect on data quality and usability, if any. This information will be compiled into a Data Validation Report included with the PDI ER.

The CPM and Contractor QAO are responsible for preparing the PDI ER. The report will be submitted to EPA and Montana DEQ for review. Upon receipt of Agency comments, prepared by EPA in consultation with Montana DEQ, the report will be revised to address the comments and re-submitted to EPA for final approval.

12.0 PROJECT MANAGEMENT AND ORGANIZATION

This section addresses project administrative functions, concerns, and goals. It also outlines the requisite organizational structure and personnel required to perform the Stress Test and the roles, duties, and responsibilities of those personnel. Figure 15 shows the overall organization of the project team for the Stress Test.

The roles and responsibilities of key individuals comprising the project team are listed below. Individuals who fill these roles are identified on the organizational chart. Any changes to project personnel will be reflected in an updated Agency-approved organizational chart. The organizational chart will include the date, revision number, and annotation with any previous and replacement personnel listed by name and responsibility. Changes will be communicated by the CPM and distributed to personnel identified on the project distribution list.

12.1 Atlantic Richfield Liability Manager

The Atlantic Richfield Liability Manager (LM), Josh Bryson, monitors the performance of contractors. The LM consults with the Contractor QAO and CPM on deficiencies and aids in finalizing resolution actions.

12.2 Atlantic Richfield Quality Assurance Manager

The Atlantic Richfield Quality Assurance Manager (QAM), Don Booth, interfaces with the Atlantic Richfield LM on company policies regarding quality and has the authority and responsibility to approve QA documents specific to the project, including this QAPP.

12.3 Contractor Project Manager

The CPM, Jackie Janosko, is responsible for scheduling all sampling work to be completed and ensuring that the work is performed according to the requirements contained herein. The CPM is also responsible for consulting with the QA personnel identified for the project regarding any deficiencies and finalizing resolution actions.

12.4 Groundwater Remedy Project Manager

The GWR PM, Mike Borduin, ensures consistency in the direction of work performed across the groundwater remedy program as part of the BPSOU CD. The GWR PM is responsible for ensuring that work product meets requirements set forth in the CD, and is consistent with the overall project schedules, goals, and work performed to meet the requirements of the CD. The GWR PM will serve in an advisory role to the CPM and QAO with respect to meeting project goals, evaluating the significance of any changes or field decisions as they fit into CD work progression, and maintaining consistency between interrelated projects.

12.5 Field Team Leader

The Field Team Leader, Jason Decker, ensures that all members of the field team review and follow the QAPP when implementing field activities. The Field Team Leader is also responsible for maintaining the QAPP. The Field Team Leader will conduct daily safety meetings, assist in field activities, and document activities in the logbook. The Field Team Leader is responsible for equipment coordination, problem solving, decision making in the field, and technical aspects of the project. Additionally, the Field Team Leader provides *on-the-ground* overviews of project implementation by observing site activities to ensure compliance with technical project requirements; Health, Safety, Security, and Environment (HSSE) requirements; and the SSHASP. Finally, the Field Team Leader identifies potential Integrity Management issues, as appropriate, and prepares required project documentation.

12.6 BTL Lead Operator

BTL Lead Operator, Brad Hollamon, is responsible for control of the computerized maintenance management system and maintaining existing infrastructure at BTL (e.g., equipment, pipes, pumps, conveyance structures, chemical dosing systems, etc.). The BTL Lead Operator (or designated alternative) serves as the Person in Charge for BTL to facilitate communication / coordination between the on-site operators and off-site personnel performing work at the BTL site. Additionally, the BTL Lead Operator (or designated alternative) is responsible for problem solving and decision making in the field to maintain BTL systems, through the duration of the Stress Test, as specified in BTL OM&M Plan (Atlantic Richfield, 2019).

12.7 Contractor Quality Assurance Officer

The Contractor QAO, Laura Moon, is responsible for reviewing field and laboratory data and evaluating data quality, including conducting on-site reviews and preparing site review reports for the QAM. The Contractor QAO represents the assigned project as the primary spokesperson on matters relating to quality management system implementation. In matters of project QA, this individual will have a direct line of communication to the QAM to ensure issues are resolved. The Contractor QAO is authorized to stop work if, in the judgment of that individual, the work is performed contrary to or in the absence of prescribed quality controls or approved methods, and further work would make it difficult or impossible to obtain acceptable results. The Contractor QAO can also stop work if completion of quality corrective actions is not acceptable.

The Contractor QAO is responsible for conducting field audits to ensure the integrity of field measurements, sample collection, and documentation. The Contractor QAO is also responsible for evaluating information from nonconformance instances, inspection reports, surveillance reports, audit and assessment reports, quality system reviews, CARs, corrective action plans, stop work orders, and other sources. The information can be used to identify trends or conditions averse to quality, which the Contractor QAO will bring to the attention of the QAM.

12.8 Safety and Health Manager

The Project Safety and Health Manager, Tara Schleeman, conducts the initial safety meeting prior to starting fieldwork. The Project Safety and Health Manager ensures that work crews comply with all site health and safety requirements and revises the applicable SSHASP for BPSOU, if necessary.

12.9 Contract Analytical Laboratory

Eurofins Test America (Eurofins) will analyze all groundwater and/or treatment lagoon samples associated with the Stress Test. Pace Analytical Laboratories (Pace) will analyze data collected as part of BTL continuing operations per an existing agreement. Eurofins will ensure that their laboratory QA personnel are familiar with the QAPP and are available to perform the work as specified. Contract laboratory personnel are responsible for reviewing final analytical reports produced by the laboratory, scheduling laboratory analyses, and supervising in-house chain of custody procedures. Eurofins is an Atlantic Richfield-approved laboratory that follows the EPA CLP SOW for Inorganic Superfund Methods (EPA, 2016).

13.0 HEALTH AND SAFETY

All work completed by Pioneer and its subcontractor during execution of the Stress Test will be performed in accordance with all procedures outlined in the applicable SSHASP for those portions of work being performed outside of the BTL boundary. All work to be conducted on the BTL site will adhere to the applicable BTL SSHASP, and personnel will be trained accordingly. Potential hazards associated with this work include the following:

- Sampling activities around open water.
- Working around loud machinery such as pumps and other equipment.
- Late or long working hours.
- Working around heavy equipment hazards.
- Exposure to heavy metals from impacted soils and groundwater.

Site-specific hazards and applicable control measures are addressed in both the Pioneer BPSOU and BTL SSHASPs. All tasks will be risk assessed prior to starting work.

14.0 SCHEDULE

Fieldwork will begin once Agency approval has been received and is anticipated to take approximately 20 weeks (the 20 week estimate includes an additional period of baseline monitoring prior to the stress test). A proposed schedule is shown on Figure 14. Work will be performed as weather conditions permit. Potential constraints that could delay fieldwork include adverse weather conditions, contractor availability, coordination with land managers/users, challenges with drilling caused by site conditions, or other unforeseen issues. Major project delays resulting from these constraints will be recorded in the field logbooks and reported to the Agencies.

15.0 REPORTING

Results of the Stress Test sampling, analyses and modeling work will be incorporated into a PDI ER. The PDI ER will include a data summary report with validated data, a data validation report, appropriate field and laboratory documentation, data evaluation and interpretation, analyses, conclusions, and recommendations.

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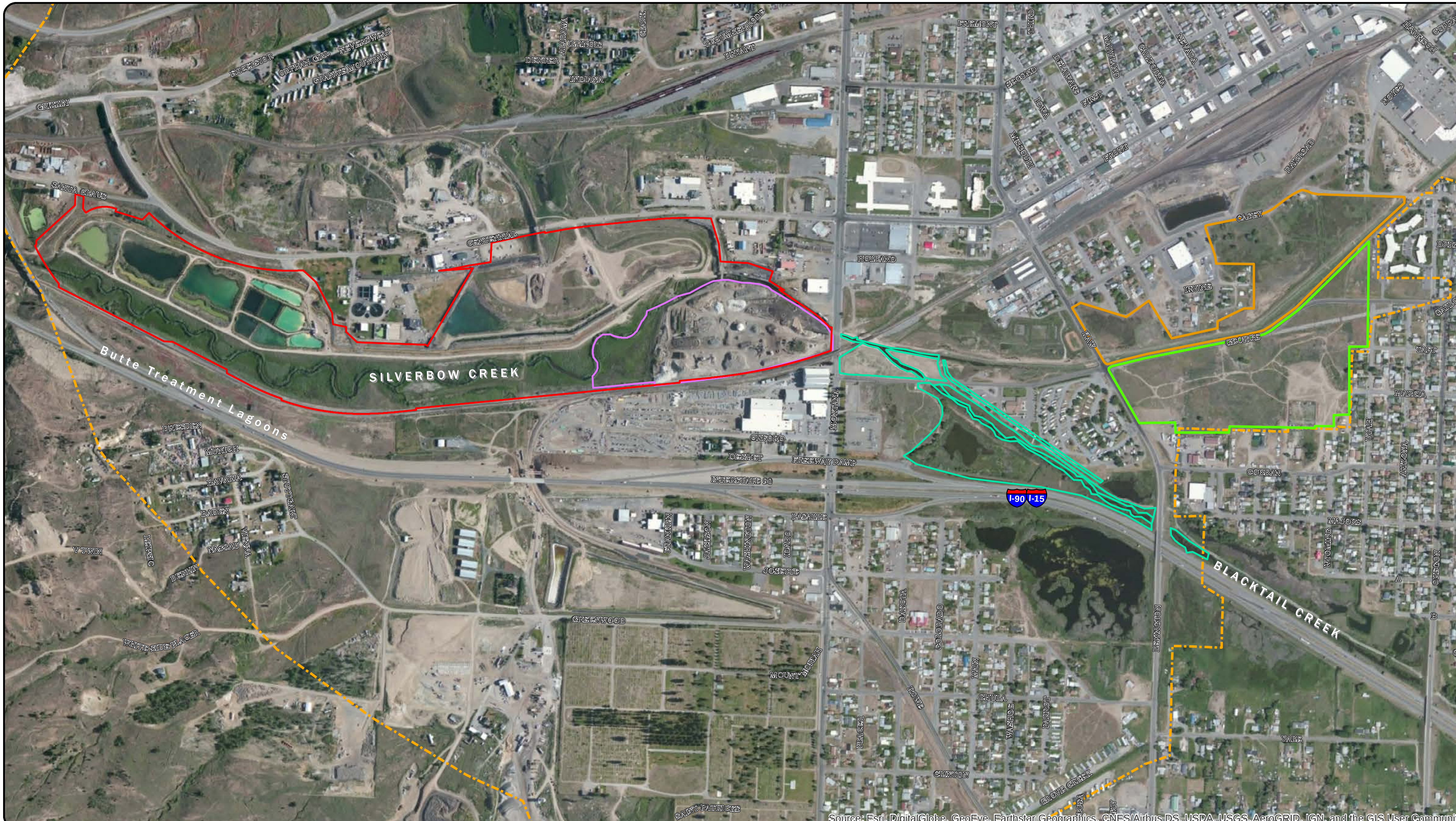
FIGURES



LEGEND

- Blacktail Creek Remediation Work Area
- Northside Boundary
- Diggings East Boundary
- LAO Boundary
- BRW Boundary
- BPSOU Boundary

N

DISPLAYED AS:
PROJECTION/ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/ESRI

0 350 700 1,400
Feet

FIGURE 1

BPSOU AREA OVERVIEW

PIONEER TECHNICAL SERVICES, INC.

DATE: 5/3/2021

Path: Z:\Shared\Active Projects\ARCO\BPSOU\GWRO\GIS\BTL_StressTest\StrsTst_BTL_001_20.mxd

LEGEND

- LAO Boundary
- BTL/LAO Treatment Cells
- Hydraulic Control Channel
- BRW Boundary
- B-SB WWTP Boundary

N

DISPLAYED AS:
PROJECTION/ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/ESRI

0 200 400 800
Feet

FIGURE 2

BTL SYSTEM COMPONENTS

PIONEER TECHNICAL SERVICES, INC.

DATE: 5/3/2021

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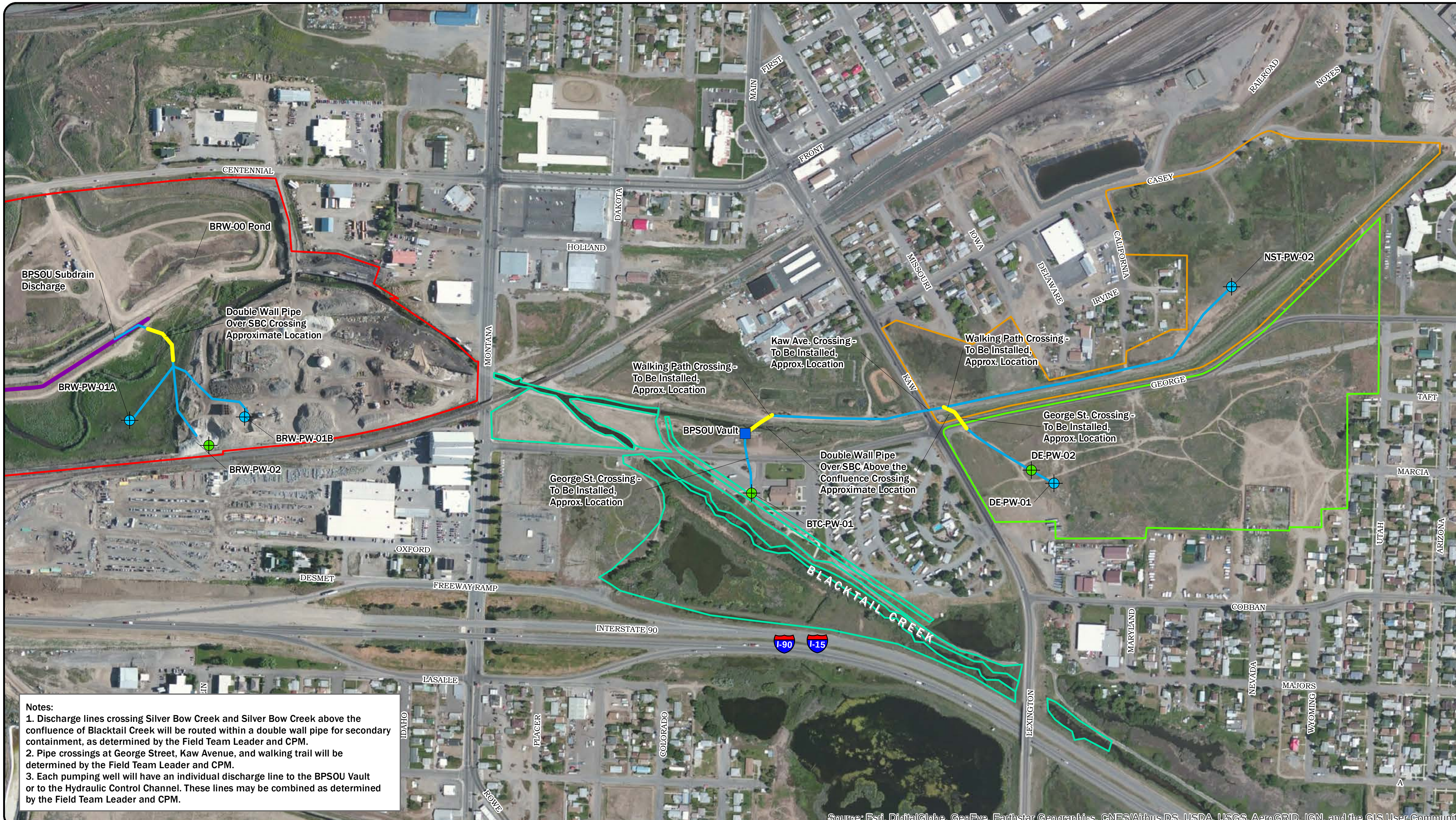

Notes:
1. Discharge lines crossing Silver Bow Creek and Silver Bow Creek above the confluence of Blacktail Creek will be routed within a double wall pipe for secondary containment, as determined by the Field Team Leader and CPM.
2. Pipe crossings at George Street, Kaw Avenue, and walking trail will be determined by the Field Team Leader and CPM.
3. Each pumping well will have an individual discharge line to the BPSOU Vault or to the Hydraulic Control Channel. These lines may be combined as determined by the Field Team Leader and CPM.

LEGEND
- Proposed Discharge Lines
- Proposed Double Wall Pipe
- Proposed Pumping Wells
- Pumping Wells
- BPSOU Vault
- Hydraulic Control Channel
- Blacktail Creek Remediation Work Area
- LAO Boundary
- Northside Boundary
- Diggings East Boundary

N

DISPLAYED AS:
PROJECTION/ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/ESRI

0 200 400 800
Feet

FIGURE 3

INFLUENT SOURCE LOCATIONS AND DISCHARGE LINE ALIGNMENTS

PIONEER TECHNICAL SERVICES, INC.

DATE: 5/3/2021

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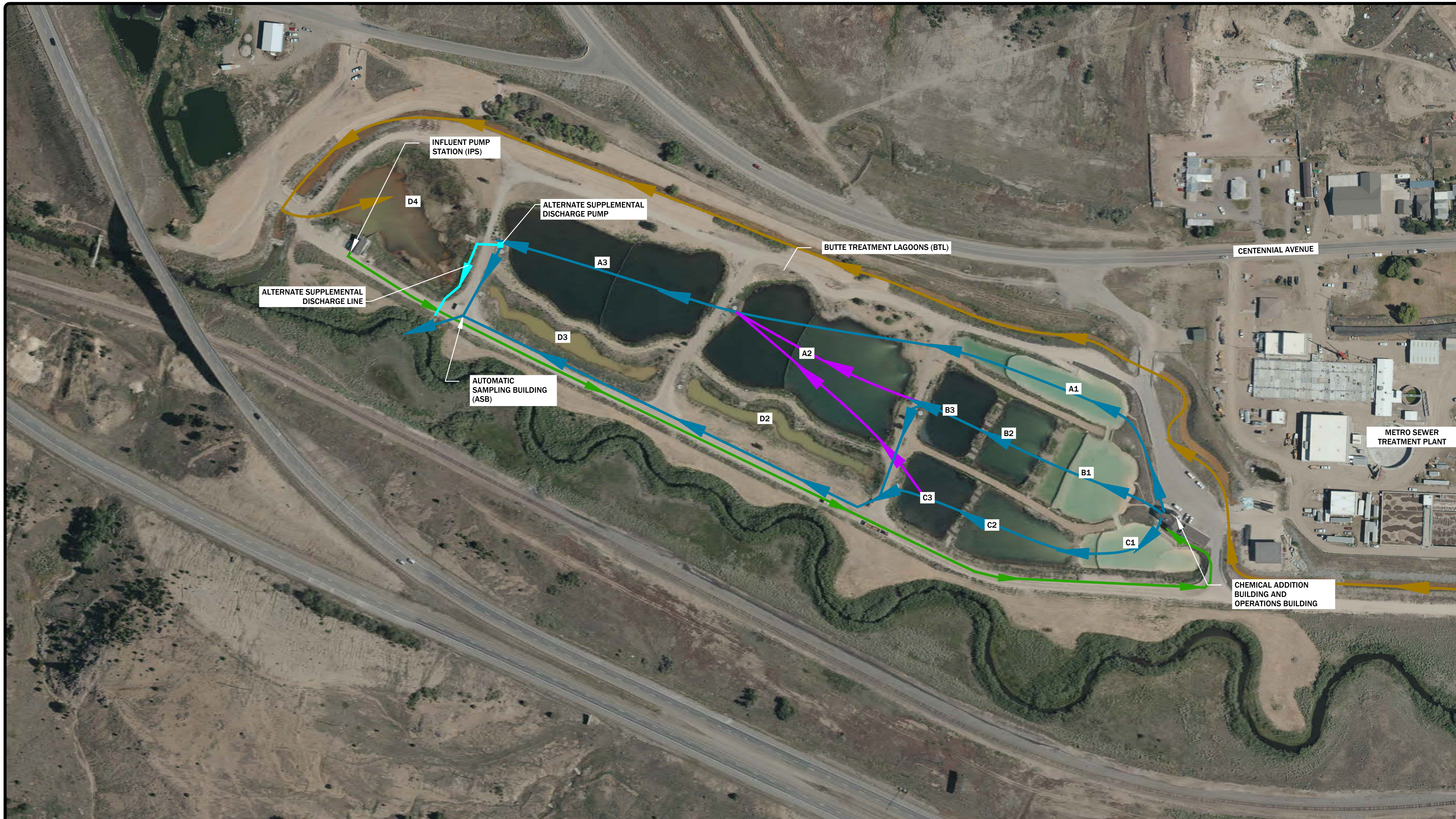


LEGEND:

- PARALLEL TREATMENT / TYPICAL SUMMER FLOW PATH
- SERIES TREATMENT / TYPICAL WINTER FLOW PATH
- HYDRAULIC CONTROL CHANNEL FLOW PATH
- INFLUENT PIPELINE(S) FLOW PATH
- ALTERNATE SUPPLEMENTAL DISCHARGE

NOTES:

1. THE PARALLEL TREATMENT FLOW PATH WILL BE USED PRIMARILY DURING THE STRESS TEST
2. THE SERIES TREATMENT MAY BE USED WHEN LONGER RETENTION TIMES ARE DESIRED
3. THE LOCATIONS OF THE ALTERNATE SUPPLEMENTAL DISCHARGE FEATURES ARE APPROXIMATE.
4. THE ALTERNATE SUPPLEMENTAL DISCHARGE PUMP AND ALTERNATE SUPPLEMENTAL DISCHARGE LINE WILL BE USED TO MAINTAIN THE NORMAL OPERATING LEVELS IN CELL A3 DURING THE STRESS TEST.

N

DISPLAYED AS:

COORD SYS/ZONE: MSP

DATUM: NAD 83

UNITS: FEET

SOURCE: PIONEER

SCALE IN FEET
0 100 200

FIGURE 4

PIONEER TECHNICAL SERVICES, INC.
307 E. PARK AVE., SUITE 421
ANACONDA, MONTANA 59711
(406) 563-9371

POTENTIAL BTL FLOW PATHS DURING THE STRESS TEST

DATE: 05/2021

LEGEND:

OHP — OVERHEAD POWER LINE

Ⓦ PUMPING WELL

NOTES:

1. THE TEMPORARY POWER SERVICE IS CONCEPTUAL IN NATURE AND SUBJECT TO CHANGE FOLLOWING COORDINATION WITH NORTHWESTERN ENERGY.

N

	DISPLAYED AS:
COORD SYS/ZONE:	MSP
DATUM:	NAD 83
UNITS:	FEET
SOURCE:	PIONEER

SCALE IN FEET: 0 50 100

FIGURE 5

PIONEER TECHNICAL SERVICES, INC.
1101 SOUTH MONTANA
BUTTE, MONTANA 59701
(406) 782-5177

BRW TEMPORARY POWER SERVICE INSTALLATION LOCATIONS

DATE: 5/2021

5/3/2021 10:34:33 AM Z:\SHARED\ACTIVE PROJECTS\ARCO\BPSOU\GWRO\CADD\FIGURES\BTL-SMA-FG-PLN-002-21.DWG

LEGEND:

UE — UNDERGROUND POWER LINE

(W) PUMPING WELL

NOTES:

1. THE TEMPORARY POWER SERVICE IS CONCEPTUAL IN NATURE AND SUBJECT TO CHANGE FOLLOWING COORDINATION WITH NORTHWESTERN ENERGY.

N

DISPLAYED AS:	
COORD SYS/ZONE:	MSP
DATUM:	NAD 83
UNITS:	FEET
SOURCE:	PIONEER

SCALE IN FEET

0 50 100

FIGURE 6

PIONEER
TECHNICAL SERVICES, INC.
1101 SOUTH MONTANA
BUTTE, MONTANA 59701
(406) 782-5177

DE & NST TEMPORARY POWER SERVICE INSTALLATION LOCATIONS

DATE: 5/2021

LEGEND:

OHP — OVERHEAD POWER LINE

W PUMPING WELL

NOTES:

1. THE TEMPORARY POWER SERVICE IS CONCEPTUAL IN NATURE AND SUBJECT TO CHANGE FOLLOWING COORDINATION WITH NORTHWESTERN ENERGY.

N

DISPLAYED AS:	
COORD SYS/ZONE:	MSP
DATUM:	NAD 83
UNITS:	FEET
SOURCE:	PIONEER

SCALE IN FEET

0 50 100

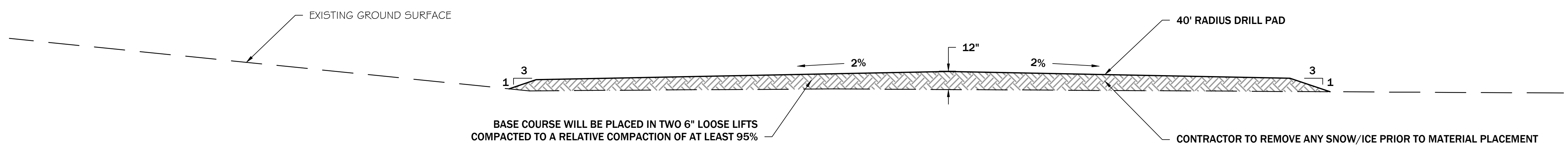
FIGURE 7

PIONEER TECHNICAL SERVICES, INC.
1101 SOUTH MONTANA
BUTTE, MONTANA 59701
(406) 782-5177

BLACKTAIL CREEK TEMPORARY POWER SERVICE INSTALLATION LOCATIONS

DATE: 5/2021

5/3/2021 10:44:35 AM Z:\SHARED\ACTIVE PROJECTS\ARCO\BPSOU\GWRO\CADD\FIGURES\BTL-SMA-FG-PLN-004-21.DWG



NOTES:

BASE COURSE MATERIAL SHALL BE OBTAINED FROM EXISTING STOCKPILES AT THE BRW SITE.

DISPLAYED AS:
COORD SYS/ZONE: N/A
DATUM: N/A
UNITS: N/A
SOURCE: PIONEER

SCALE IN FEET
0 N.T.S.

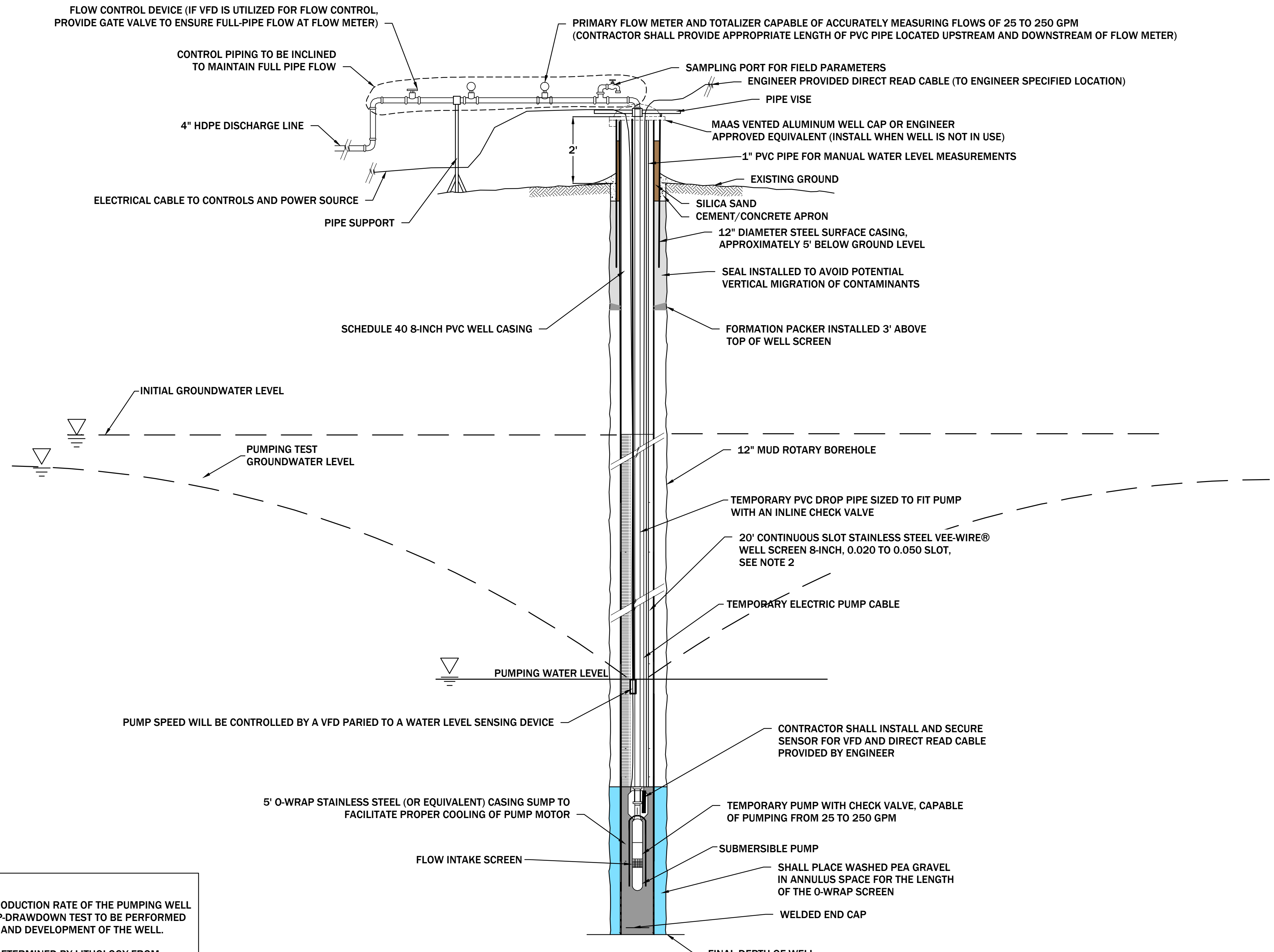
FIGURE 8

PIONEER TECHNICAL SERVICES, INC.

1101 SOUTH MONTANA
BUTTE, MONTANA 59701
(406) 782-5177

DRILL PAD
FOR WELL
TYPICAL SECTION

DATE: 5/2021



PUMPING WELL INSTALLATION DETAIL

N.T.S.

NOTES:

1. VERIFICATION OF GENERAL PRODUCTION RATE OF THE PUMPING WELL WILL BE ESTIMATED BY A STEP-DRAWDOWN TEST TO BE PERFORMED FOLLOWING THE COMPLETION AND DEVELOPMENT OF THE WELL.
2. WELL SCREEN TYPE WILL BE DETERMINED BY LITHOLOGY FROM GEOPROBE BOREHOLE(S).

DISPLAYED AS:	
COORD SYS/ZONE:	NA
DATUM:	NA
UNITS:	FEET
SOURCE:	PIONEER

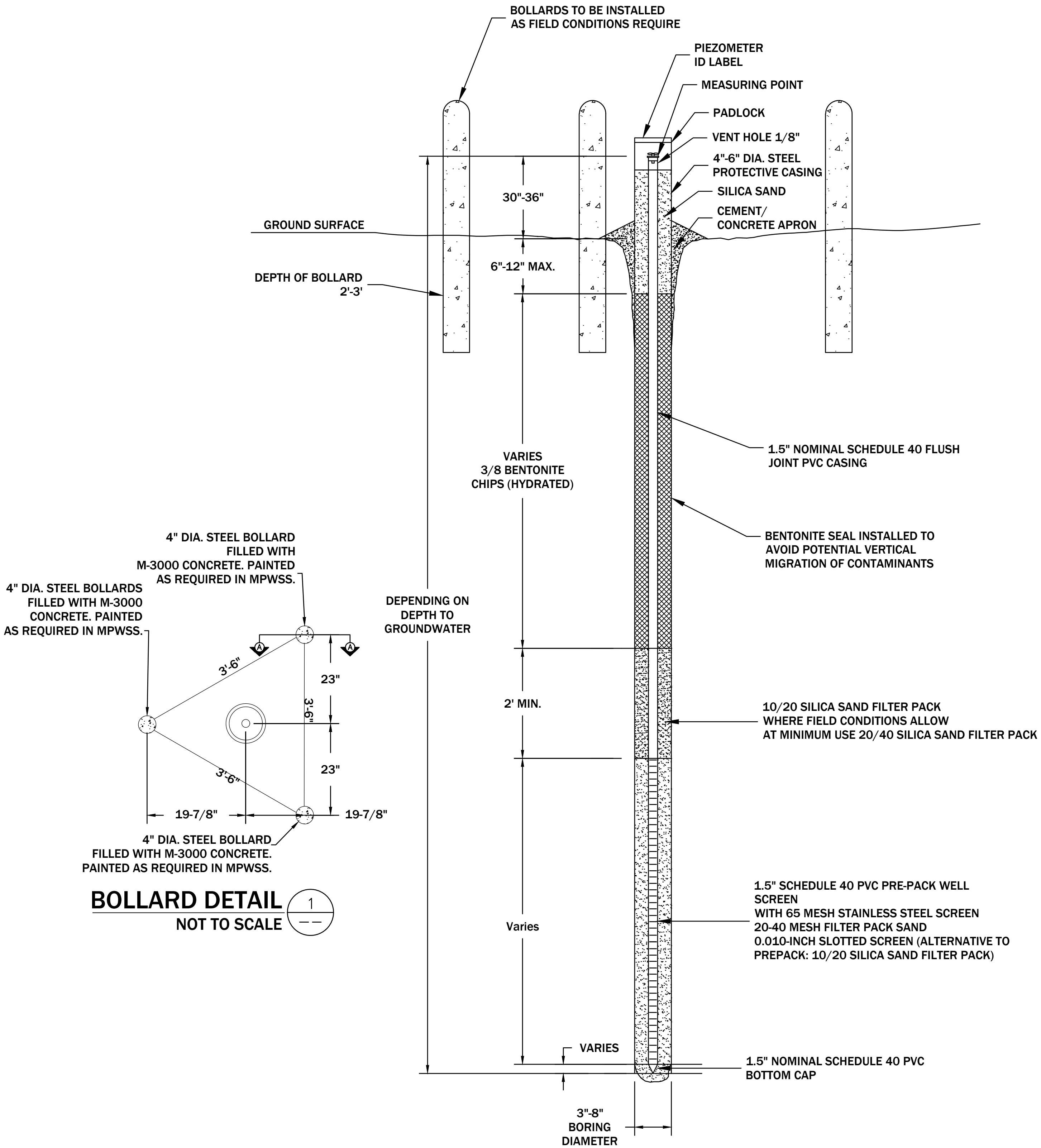
SCALE IN FEET
0 N.T.S.

FIGURE 9

PUMPING WELL CONSTRUCTION DETAIL

PIONEER TECHNICAL SERVICES, INC.
1101 SOUTH MONTANA
BUTTE, MONTANA 59701
(406) 782-5177

DATE: 5/2021



DISPLAYED AS:	
COORD SYS/ZONE:	N/A
DATUM:	N/A
UNITS:	N/A
SOURCE:	PIONEER

SCALE IN FEET
0 NTS

FIGURE 10

PIONEER TECHNICAL SERVICES, INC.

PIEZOMETER CONSTRUCTION DETAIL

DATE: 5/2021

z:\shared\active projects\arco\bpsou\gwro\cadd\figures\btl-sma-fg-det-003-21.dwg

LEGEND

- Pumping Well
- Monitoring Piezometer
- LAO Boundary

N

DISPLAYED AS:
PROJECTION/ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/ESRI

0 100 200 400
Feet

FIGURE 11

PIONEER TECHNICAL SERVICES, INC.

DATE: 5/3/2021

BRW AREA GROUNDWATER MONITORING

Path: Z:\Shared\Active Projects\ARCO\BPSOU\GWRO\GIS\BTL_StressTest\StrsTst_BTL_004_20.mxd

LEGEND

- Pumping Wells
- Monitoring Wells
- BPSOU Subdrain
- Blacktail Creek Remediation Work Area
- Northside Boundary
- Diggings East Boundary

N

DISPLAYED AS:
PROJECTION/ZONE: MSP
DATUM: NAD 83
UNITS: INTERNATIONAL FEET
SOURCE: PIONEER/ESRI

0 100 200 400
Feet

FIGURE 12

PIONEER TECHNICAL SERVICES, INC.

DE/NST AREA GROUNDWATER MONITORING

DATE: 5/3/2021

Path: Z:\Shared\Active Projects\ARCO\BPSOU\GWRO\GIS\BTL_StressTest\StrsTst_BTL_005_20.mxd

LEGEND:

SAMPLE POINTS

NOTE: THE LOCATIONS OF THE SAMPLE POINTS ARE APPROXIMATE.

N

	DISPLAYED AS:
COORD SYS/ZONE:	MSP
DATUM:	NAD 83
UNITS:	FEET
SOURCE:	PIONEER

SCALE IN FEET
0 100 200

FIGURE 13

PIONEER TECHNICAL SERVICES, INC.
1101 SOUTH MONTANA
BUTTE, MONTANA 59701
(406) 782-5177

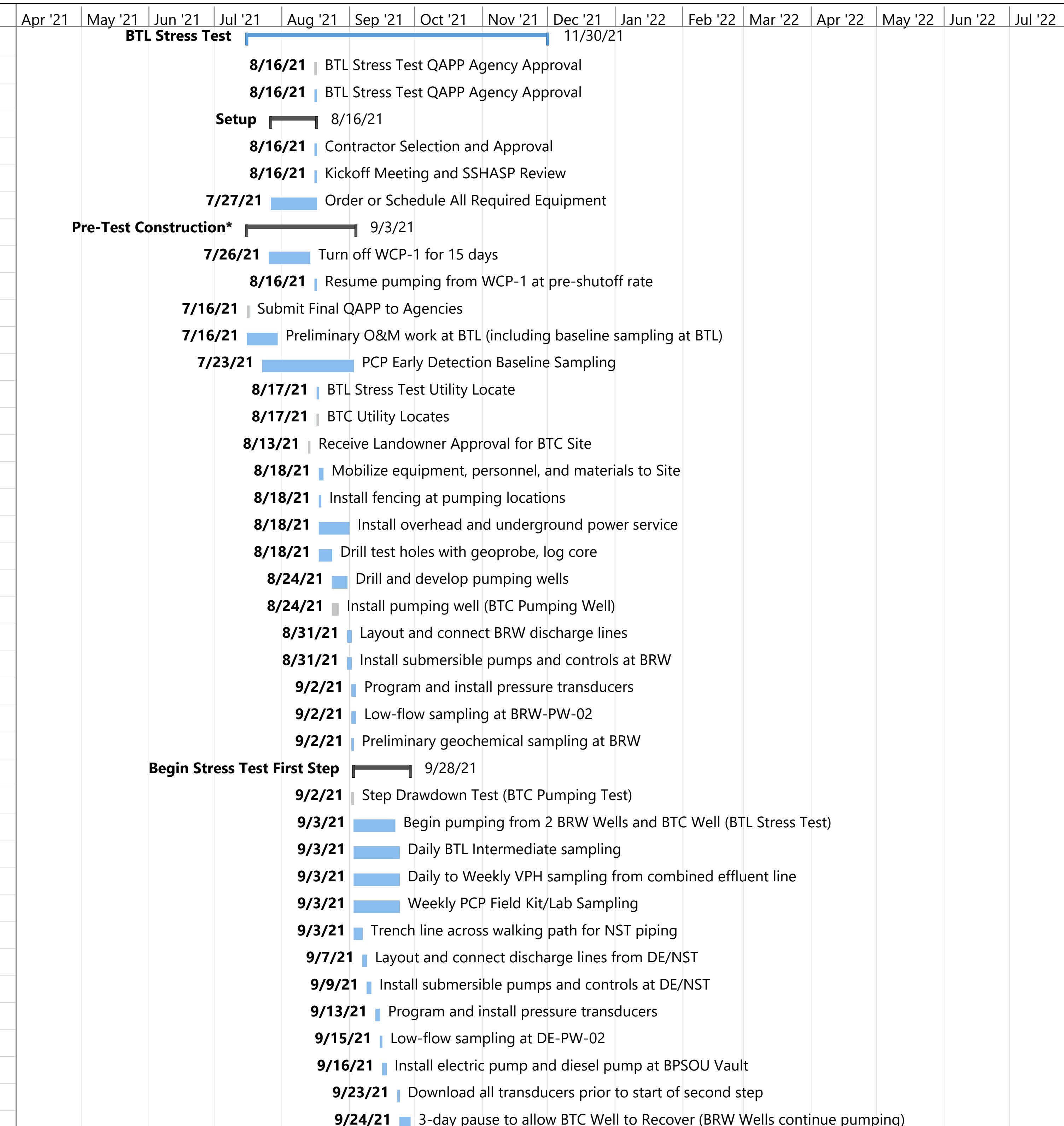
BTL SAMPLE LOCATIONS

DATE: 5/2021

5/3/2021 10:16:11 AM Z:\SHARED\ACTIVE PROJECTS\ARCO\BPSOU\GWRO\CADD\FIGURES\BTL-SMA-FG-PLN-001-21.DWG

Figure 14. Proposed Project Schedule

ID	Task Name	Duration	Start	Finish
0	**BTL Stress Test**	**98 days**	**Fri 7/16/21**	**Tue 11/30/21**
1	BTL Stress Test QAPP Agency Approval	1 day	Mon 8/16/21	Mon 8/16/21
2	BTL Stress Test QAPP Agency Approval	1 day	Mon 8/16/21	Mon 8/16/21
3	**Setup**	**15 days**	**Tue 7/27/21**	**Mon 8/16/21**
4	Contractor Selection and Approval	1 day	Mon 8/16/21	Mon 8/16/21
5	Kickoff Meeting and SSHASP Review	1 day	Mon 8/16/21	Mon 8/16/21
6	Order or Schedule All Required Equipment	15 days	Tue 7/27/21	Mon 8/16/21
7	**Pre-Test Construction***	**36 days**	**Fri 7/16/21**	**Fri 9/3/21**
8	Turn off WCP-1 for 15 days	15 days	Mon 7/26/21	Fri 8/13/21
9	Resume pumping from WCP-1 at pre-shutoff rate	1 day	Mon 8/16/21	Mon 8/16/21
10	Submit Final QAPP to Agencies	1 day	Fri 7/16/21	Fri 7/16/21
11	Preliminary O&M work at BTL (including baseline sampling at BTL)	10 days	Fri 7/16/21	Thu 7/29/21
12	PCP Early Detection Baseline Sampling	6 wks	Fri 7/23/21	Thu 9/2/21
13	BTL Stress Test Utility Locate	1 day	Tue 8/17/21	Tue 8/17/21
14	BTC Utility Locates	1 day	Tue 8/17/21	Tue 8/17/21
15	Receive Landowner Approval for BTC Site	1 day	Fri 8/13/21	Fri 8/13/21
16	Mobilize equipment, personnel, and materials to Site	2 days	Wed 8/18/21	Thu 8/19/21
17	Install fencing at pumping locations	1 day	Wed 8/18/21	Wed 8/18/21
18	Install overhead and underground power service	10 days	Wed 8/18/21	Tue 8/31/21
19	Drill test holes with geoprobe, log core	4 days	Wed 8/18/21	Mon 8/23/21
20	Drill and develop pumping wells	5 days	Tue 8/24/21	Mon 8/30/21
21	Install pumping well (BTC Pumping Well)	3 days	Tue 8/24/21	Thu 8/26/21
22	Layout and connect BRW discharge lines	2 days	Tue 8/31/21	Wed 9/1/21
23	Install submersible pumps and controls at BRW	2 days	Tue 8/31/21	Wed 9/1/21
24	Program and install pressure transducers	2 days	Thu 9/2/21	Fri 9/3/21
25	Low-flow sampling at BRW-PW-02	2 days	Thu 9/2/21	Fri 9/3/21
26	Preliminary geochemical sampling at BRW	1 day	Thu 9/2/21	Thu 9/2/21
27	**Begin Stress Test First Step**	**18 days**	**Fri 9/3/21**	**Tue 9/28/21**
28	Step Drawdown Test (BTC Pumping Test)	1 day	Thu 9/2/21	Thu 9/2/21
29	Begin pumping from 2 BRW Wells and BTC Well (BTL Stress Test)	13 days	Fri 9/3/21	Tue 9/21/21
30	Daily BTL Intermediate sampling	15 days	Fri 9/3/21	Thu 9/23/21
31	Daily to Weekly VPH sampling from combined effluent line	15 days	Fri 9/3/21	Thu 9/23/21
32	Weekly PCP Field Kit/Lab Sampling	15 days	Fri 9/3/21	Thu 9/23/21
33	Trench line across walking path for NST piping	2 days	Fri 9/3/21	Mon 9/6/21
34	Layout and connect discharge lines from DE/NST	2 days	Tue 9/7/21	Wed 9/8/21
35	Install submersible pumps and controls at DE/NST	2 days	Thu 9/9/21	Fri 9/10/21
36	Program and install pressure transducers	2 days	Mon 9/13/21	Tue 9/14/21
37	Low-flow sampling at DE-PW-02	1 day	Wed 9/15/21	Wed 9/15/21
38	Install electric pump and diesel pump at BPSOU Vault	2 days	Thu 9/16/21	Fri 9/17/21
39	Download all transducers prior to start of second step	1 day	Thu 9/23/21	Thu 9/23/21
40	3-day pause to allow BTC Well to Recover (BRW Wells continue pumping)	3 days	Fri 9/24/21	Tue 9/28/21



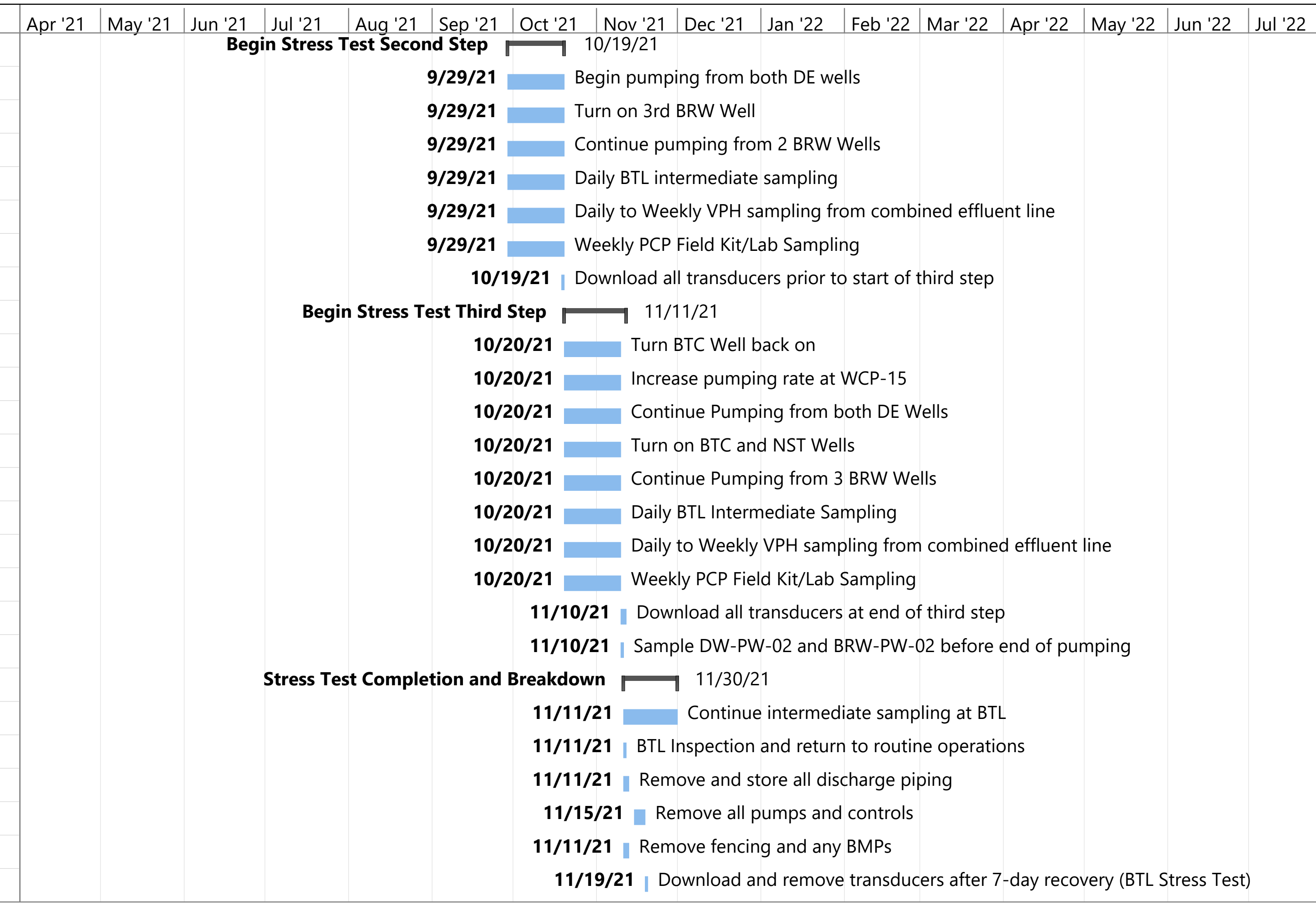
Project: BTL Stress Test*
Date: Mon 5/3/21

Legend: Task; Summary; Project Summary; External Tasks (QAPP, PDI ER, BTC Pumping Test)

*Additional details on the BTC Pumping Test Schedule are in the BTC Pumping Test QAPP

Figure 14. Proposed Project Schedule

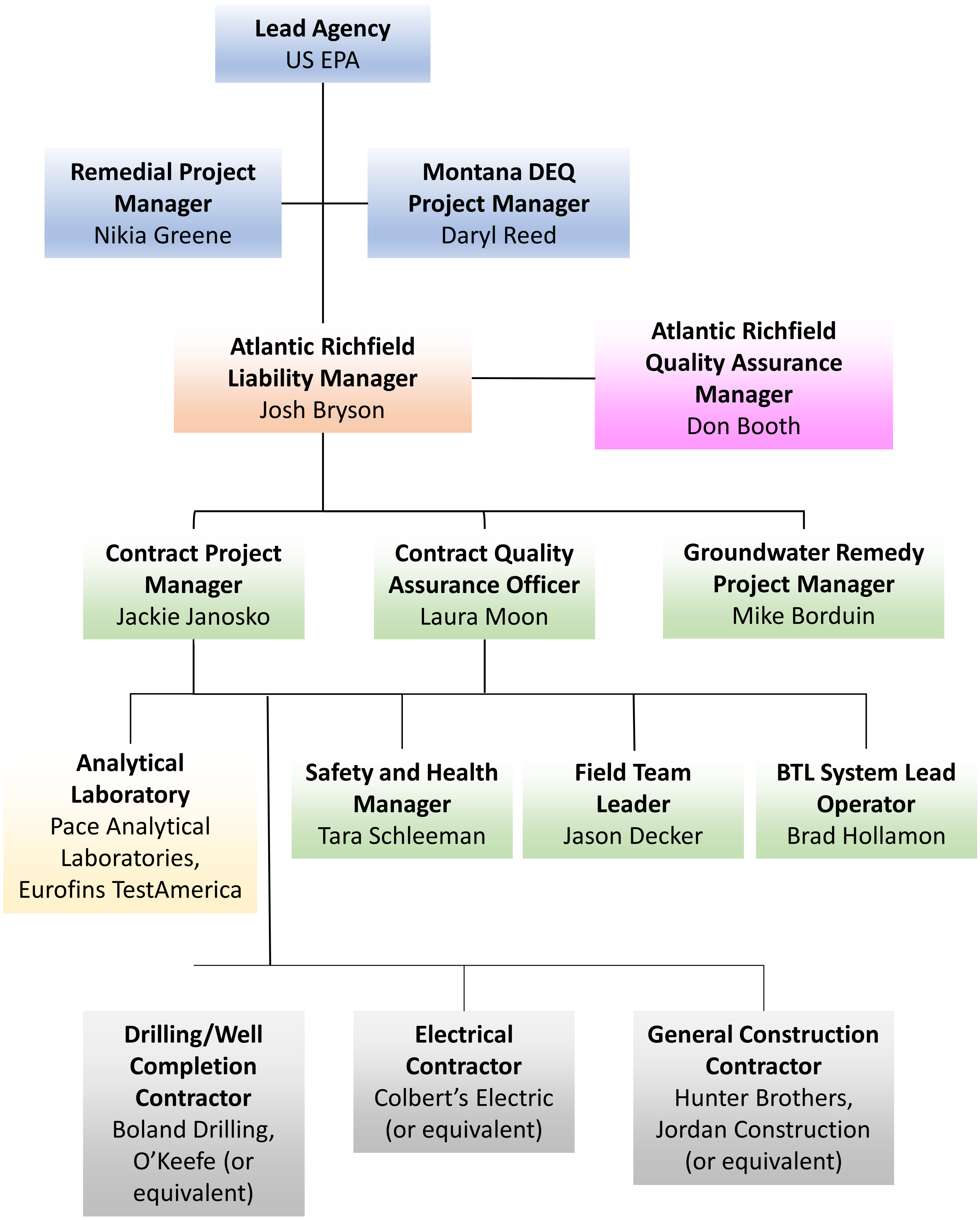
ID	Task Name	Duration	Start	Finish
41	**Begin Stress Test Second Step**	**15 days**	**Wed 9/29/21**	**Tue 10/19/21**
42	Begin pumping from both DE wells	15 days	Wed 9/29/21	Tue 10/19/21
43	Turn on 3rd BRW Well	15 days	Wed 9/29/21	Tue 10/19/21
44	Continue pumping from 2 BRW Wells	15 days	Wed 9/29/21	Tue 10/19/21
45	Daily BTL intermediate sampling	15 days	Wed 9/29/21	Tue 10/19/21
46	Daily to Weekly VPH sampling from combined effluent line	15 days	Wed 9/29/21	Tue 10/19/21
47	Weekly PCP Field Kit/Lab Sampling	15 days	Wed 9/29/21	Tue 10/19/21
48	Download all transducers prior to start of third step	1 day	Tue 10/19/21	Tue 10/19/21
49	**Begin Stress Test Third Step**	**17 days**	**Wed 10/20/21**	**Thu 11/11/21**
50	Turn BTC Well back on	15 days	Wed 10/20/21	Tue 11/9/21
51	Increase pumping rate at WCP-15	15 days	Wed 10/20/21	Tue 11/9/21
52	Continue Pumping from both DE Wells	15 days	Wed 10/20/21	Tue 11/9/21
53	Turn on BTC and NST Wells	15 days	Wed 10/20/21	Tue 11/9/21
54	Continue Pumping from 3 BRW Wells	15 days	Wed 10/20/21	Tue 11/9/21
55	Daily BTL Intermediate Sampling	15 days	Wed 10/20/21	Tue 11/9/21
56	Daily to Weekly VPH sampling from combined effluent line	15 days	Wed 10/20/21	Tue 11/9/21
57	Weekly PCP Field Kit/Lab Sampling	15 days	Wed 10/20/21	Tue 11/9/21
58	Download all transducers at end of third step	2 days	Wed 11/10/21	Thu 11/11/21
59	Sample DW-PW-02 and BRW-PW-02 before end of pumping	1 day	Wed 11/10/21	Wed 11/10/21
60	**Stress Test Completion and Breakdown**	**14 days**	**Thu 11/11/21**	**Tue 11/30/21**
61	Continue intermediate sampling at BTL	14 days	Thu 11/11/21	Tue 11/30/21
62	BTL Inspection and return to routine operations	1 day	Thu 11/11/21	Thu 11/11/21
63	Remove and store all discharge piping	2 days	Thu 11/11/21	Fri 11/12/21
64	Remove all pumps and controls	4 days	Mon 11/15/21	Thu 11/18/21
65	Remove fencing and any BMPs	2 days	Thu 11/11/21	Fri 11/12/21
66	Download and remove transducers after 7-day recovery (BTL Stress Test)	1 day	Fri 11/19/21	Fri 11/19/21



Project: BTL Stress Test*
Date: Mon 5/3/21

Task	(legend bar)	Project Summary	(legend bar)
Summary	(legend bar)	External Tasks (QAPP, PDI ER, BTC Pumping Test)	(legend bar)

*Additional details on the BTC Pumping Test Schedule are in the BTC Pumping Test QAPP



PIONEER TECHNICAL SERVICES, INC.

Figure 15: Organization of the Project Team

TABLES

Table 1: Current BTL Discharge Standards and Proposed Test Suspension Values (µg/L)

Constituent	Current Standard[1] Value[0]	Current Standard[1] Measured as	Proposed Test Suspension Value[2] Value[0]	Proposed Test Suspension Value[2] Measured as	Notes on the Test Suspension Value	Notes on the Effluent Concentrations at BTL[3]
Aluminum	87	D	87	D	Maintain Existing Standard[1]	Maximum observed concentration is 88 µg/L, 95th percentile concentration is 27 µg/L, and average concentration is 10.4 µg/L.
Arsenic (Total)	10	TR	150	D	National Freshwater CCC / Chronic Aquatic Standard[4]	Maximum observed concentration is 9.90 µg/L, 95th percentile concentration is 5.90 µg/L, and average concentration is 4.30 µg/L.
Cadmium	0.756	TR	2.03	D	National Freshwater CCC / Chronic Aquatic Standard[4]	Maximum observed concentration is 1.50 µg/L, 95th percentile concentration is 0.45 µg/L, and average concentration is 0.236 µg/L.
Copper	30.5	TR	29.3	D	National Chronic Aquatic Standard before the Biotic Ligand Model[5]	Maximum observed concentration is 36.0 µg/L, 95th percentile concentration is 17.0 µg/L, and average concentration is 11.2 µg/L.
Iron	1000	TR	1000	D	National Freshwater CCC / Chronic Aquatic Standard[4]	Maximum observed concentration is 220 µg/L, 95th percentile concentration is 50.6 µg/L, and average concentration is 25.5 µg/L.
Lead	18.6	TR	10.9	D	National Freshwater CCC / Chronic Aquatic Standard[4]	Maximum observed concentration is 2.30 µg/L, 95th percentile concentration is 0.52 µg/L, and average concentration is 0.225 µg/L.
Mercury	0.05	TR	0.65	D	National Freshwater CCC / Chronic Aquatic Standard[4]	Excluding non-detect values, the maximum observed concentration is 0.0580 µg/L (however, mercury was detected in the method blank for this analysis), 95th percentile concentration is 0.0090 µg/L, and average concentration is 0.0065 µg/L.
Silver	44.0	TR	43.4	D	National Freshwater CMC / Acute Aquatic Standard[4,9]	Maximum observed concentration is 0.190 µg/L, 95th percentile concentration is 0.170 µg/L, and average concentration is 0.109 µg/L.
Zinc	388	TR	382	D	National Freshwater CCC / Chronic Aquatic Standard[4]	Maximum observed concentration is 320 µg/L, 95th percentile concentration is 100 µg/L, and average concentration is 60.5 µg/L.

D = Dissolved Fraction

TR = Total Recoverable Fraction

[0] for hardness dependent criteria a hardness of 400mg/L was used.

[1] Consent Decree for the Butte Priority Soils Operable Unit. Partial Remedial Design/Remedial Action and Operation and Maintenance. U.S. Environmental Protection Agency. February 13, 2020. Specifically Table 8-1 Butte Treatment Lagoon Discharge Standards After Conclusion of any Shakedown Period in Attachment A to Appendix D of the BPSOU CD. Available at https://www.co.silverbow.mt.us/2161/ButtePriority-Soils-Operable-Unit-Conse

[2] The proposed test suspension values were selected to allow the BTL Stress Test to exceed the chemistry currently seen at BTL[4] while remaining protective of Silver Bow Creek. The compliance point will remain at the current discharge station at BTL[1].

[3] The notes on the effluent concentrations at BTL includes the effluent discharge concentrations at BTL between 2017 and 2020. The concentrations are measured (total recoverable or dissolved) to match the current standards[1].

[4] National Recommended Water Quality Criteria - Aquatic Life Criteria Table. United States Environmental Protection Agency. Last Updated October 15, 2020. Available at https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table#table

[5] The copper criteria will use the National Chronic Aquatic Standard in place before the 2007 update to the Biotic Ligand Model[6]. The standard was hardness based with a dissolved conversion factor. This standard is still in use as a state standard in some states. For example, the State of Washington[7] uses this standard. The formula for calculating the standard is as follows:

$$Copper\ Standard = 0.960\ EXP\{0.8545[\ln(hardness)] - 1.702\}$$

[6] 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water. United States Environmental Protection Agency. September 1996. Available at https://www.epa.gov/sites/production/files/2019-03/documents/1995-updates-wqc-protection-al.pdf

[7] WAC 173-201A-240 Toxic Substances. Washington State Legislature. Effective January 30, 2020. Available at https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-240.

[8] Circular DEQ-7 Montana Numeric Water Quality Standards. Montana Department of Environmental Quality. June 2019. Available at https://deq.mt.gov/Portals/112/Water/WQPB/Standards/PDF/DEQ7/DEQ-7.pdf

[9] There is no chronic aquatic standard in the BPSOU CD[1], National Standards[4], or MT DEQ-7 Standards[8].

Table 2: Summary of Compliance at BTL: January 2014 to December 2020

Description: This table provides a summary of the compliance metrics at the BTL effluent (CT-EFS7). These metrics are compiled by year from 2014 to 2020 and also include a total summary for the years 2014 through 2020.

Analyte/Parameter	Basis	Standard (µg/L)	Reference	Compliance																							
				2014[2]			2015[2,3]			2016			2017			2018			2019			2020[4]			Total		
				Sample Count	Exceedances	% Compliance	Sample Count	Exceedances	% Compliance	Sample Count	Exceedances	% Compliance	Sample Count	Exceedances	% Compliance	Sample Count	Exceedances	% Compliance	Sample Count	Exceedances	% Compliance	Sample Count	Exceedances	% Compliance	Sample Count	Exceedances	% Compliance
Aluminum	Dis[1]	87	Chronic aquatic standard	208	7	97%	105	1	99%	101	2	98%	104	1	99%	103	0	100%	105	0	100%	105	0	100%	**831**	**11**	**98.7%**
Arsenic	TR	10	Human health standard	208	0	100%	105	0	100%	101	0	100%	104	0	100%	103	0	100%	105	0	100%	105	0	100%	**831**	**0**	**100.0%**
Cadmium	TR	0.76	Chronic aquatic standard*	208	0	100%	105	0	100%	101	1	99%	104	0	100%	103	1	99%	105	4	96%	105	2	98%	**831**	**8**	**99.0%**
Copper	TR	30.5	Chronic aquatic standard*	208	0	100%	105	0	100%	101	1	99%	104	0	100%	103	0	100%	105	0	100%	105	2	98%	**831**	**3**	**99.6%**
Lead	TR	15	Human health standard	208	0	100%	105	0	100%	101	0	100%	104	0	100%	103	0	100%	105	0	100%	105	0	100%	**831**	**0**	**100.0%**
Iron	TR	1000	Chronic aquatic standard	208	0	100%	105	0	100%	101	0	100%	104	0	100%	103	0	100%	105	0	100%	105	0	100%	**831**	**0**	**100.0%**
Mercury	TR	0.05	Human health standard	208	0	100%	105	3	97%	101	1	99%	104	28 [4]	73%	103	0	100%	105	0	100%	105	8 [4]	92%	**831**	**40**	**95.2%**
Silver	TR	44	Acute aquatic standard*	208	0	100%	105	0	100%	101	0	100%	104	0	100%	103	0	100%	105	0	100%	105	0	100%	**831**	**0**	**100.0%**
Zinc	TR	388	Chronic aquatic standard*	208	0	100%	105	0	100%	101	0	100%	104	0	100%	103	0	100%	105	0	100%	105	0	100%	**831**	**0**	**100.0%**
pH	Field	6.5 to 9.5 SU	Chronic aquatic standard*	365	14	**96.2%**	365	19	**94.8%**	366	4	**98.9%**	362	0	100%	**361**	**0**	**100.0%**	**369**	**1**	**99.7%**	**365**	**0**	**100.0%**	**2,553**	**38**	**98.5%**

Notes

*µg/L @ 400 mg/L as CaCO3

[1]Measured as total recoverable

[2]Butte Treatment Lagoons under construction

[3]Construction dewatering from Butte-Silver Bow sent to BTL until 5/1/2015

[4]Values are non-detect, detection limit is above standard. After August 24, 2017 analytical method changed so detection limit is below standard. In 2020, the **detection limit was increased for above the standard for the 8 samples that exceeded.**

Abbreviations

Dis: Dissolved

TR: Total Recoverable

SU: Standard Units

Table 3: Data Quality Objectives

1. BTL Physical Capacity Evaluation	2. BTL Chemical Breakthrough Evaluation	3. Additional Groundwater Source Monitoring
Estimation Problem	*Estimation Problem*	*Estimation Problem*
This table lists the data quality objectives (DQOs) for the two primary components of the Butte Treatment Lagoon (BTL) Stress Test Quality Assurance Project Plan (QAPP).		
Step 1: State the Problem: *The purpose of this step is to describe the problem to be studied so that the focus of the investigation will not be ambiguous.*		
Problem: The BTL system is comprised of a series of flow conveyance components with varying physical flow/volume capacities. The assumed design maximum flow capacity is 1,880 gallons per minute (gpm), but all system components will not respond to high flow equally. Limiting components of the BTL system are outlined in Appendix B.1 of the Capture and Treatment Performance Evaluation Scoping Document (Atlantic Richfield, 2020a). Potentially limiting components will be carefully observed during increased flow conditions and recommendations for upgrades or modifications may result. Maximum BTL flows will need to be estimated under the current treatment system configuration, and any operational or physical modifications/upgrades that may expand capacity will be identified and discussed; minor modifications may be implemented by the BTL Lead Operator, in consultation with the Field Team Leader, Contractor Project Manager (CPM) and Contractor Quality Assurance Officer (QAO). A combination of existing pumping wells and 3 additional proposed pumping wells will be required to provide sufficient representative influent to observe BTL conditions at design capacity flows.	Problem: The upper end of successful BTL treatment flow capacity has never been formally tested or evaluated beyond hypothetical design maximum. As new sources of Butte Priority Soils Operable Unit (BPSOU) groundwater associated with the Consent Decree (CD) (EPA, 2020) remedial actions come online, the actual treatment capacity of BTL will need to be estimated to determine the need for additional treatment installations. Determining the maximum flow BTL can sustain at current effluent discharge standard compliance will be important to understanding the short- and long-term BPSOU water balance.	Problem: During the Stress Test, impacted groundwater will be pumped to BTL from 4 existing pumping wells and 3 proposed pumping wells. The proposed pumping wells will include 1 installed in the Diggings East Stormwater Basin Area (DE) and 1 installed at the Butte Reduction Works (BRW) Site, which will be located within or near design excavation areas. The third well will be installed at the Blacktail Creek area for an upcoming pumping test, possibly performed simultaneous to the Stress Test. It is anticipated that 6-8 weeks of groundwater pumping is required as part of the Stress Test; at remedial sites where dewatering and excavation is planned, the groundwater response to pumping may provide insight for remedial design. Groundwater elevation data from pumping wells and select monitoring locations used for the Stress Test, as well as analytical chemistry data from newly installed pumping wells, will be collected and made available for remedial design purposes as well as fulfilling Stress Test project goals.
Planning Team: The Stress Test QAPP includes a detailed description on the project organization and responsibilities (Section 12.0). Available Resources and Schedule: Pioneer Technical Services Inc. (Pioneer) is the Contractor responsible for conducting the Stress Test per the QAPP. All personnel completing field work will be properly trained for performing their tasks. The laboratory(s) selected to analyze any water samples will be an Atlantic Richfield-approved laboratory. The Stress Test is expected to begin in July-August 2021. Installation of three additional pumping wells must occur before this time frame; well installation contractors are available regionally in this time frame.		
Step 2: Identify the Goals of the Study: *This step identifies the principal questions that the study will attempt to resolve and what actions may result.*		
Principal Study Questions: The goal of the study is to determine the largest influent flow that the BTL physical infrastructure can maintain within a margin of safety (e.g., below warning alarm system thresholds), and what the limiting system components are to increasing flow. Study questions include: • What physical modifications would be most effective at increasing BTL capacity? • Are there any potential safety concerns associated with sustained high flow? • Which system components may need additional maintenance or replacement at sustained high flow? • How does the lime demand change, and does that create any operational changes? • Will significant changes to Operations, Maintenance, and Monitoring (OM&M) procedures be required as a result of sustained increases in flow? • Which system alarms are triggered by high flow, and should the functional alarm setpoints be reevaluated? • What is the highest flow transmittable by the existing effluent lines while remaining below safe operational elevations in the treatment cells?	Principal Study Questions: The goal of the study is to determine the operational maximum flows at BTL while maintaining treatment to the relevant surface water discharge standards. Principal study questions include: • Can the BTL maintain treatment compliance at current levels with additional flows? • Does the BTL have sufficient residence time to successfully treat new sources of additional flow? • What are the governing geochemical processes that limit an increase of flow to BTL beyond the theoretical design capacity? • What modifications to the lime dosing rate will be necessary to treat the additional flows and different chemistries? • Will flow steps be representative of future conditions? • Will the pH REdox EQuilibrium Version C (PHREEQC) geochemical model be representative of site conditions, and can it be used as a predictive tool? • Are there any unforeseen changes to the BTL system under sustained high influent flow rates (e.g., treatment breakthrough)? • Will physical modifications to the operations lead to significant increases in effective treatment capacity? • Will chemical limitations or physical changes be more critical to expansion? • Will sustained pumping in the BRW area result in detectable concentrations of total petroleum hydrocarbon (TPH) or the migration of pentachlorophenol (PCP) into Lower Area One (LAO)?	Principal Study Questions: The goal of the study is to determine the physical and chemical groundwater response to pumping from wells used to provide additional influent for the Stress Test. Principal study questions include: • Do the additional pumping wells installed at the BRW and DE Sites exhibit different chemical characteristics than existing wells? • How do simultaneously pumped wells in the BRW and DE Sites influence each other and the groundwater gradient? • Do aquifer physical or chemical characteristics exhibit temporal trends over the extended pumping period? • Are boundary conditions static over the extended pumping period? • Does extended pumping reveal any unanticipated technical or logistical challenges for dewatering design? • Does extended pumping at the BRW Site result in detectable increases in field-measured hydrocarbons, or any detection of PCP or dioxins at the Site's western and southern boundaries?
Estimation Statement: The principal study questions will be answered by conducting a Stress Test using water impacted from historical mining activities from a number of sources within the BPSOU area and monitoring conditions at BTL with both the existing and additional monitoring systems.		

1. BTL Physical Capacity Evaluation	2. BTL Chemical Breakthrough Evaluation	3. Additional Groundwater Source Monitoring
Estimation Problem	*Estimation Problem*	*Estimation Problem*
Step 3: Identify Information Inputs: *The purpose of this step is to identify the informational variables that will be required to answer the principal study questions and determine which variables require environmental measurements.*		
Types of information that are needed: Physical flow capacity and physical system response to increases in flow will be carefully monitored through the duration of the Stress Test. Information collected to support this evaluation will include the following: • Influent and effluent flow rates. • Photographs of system components (i.e., sluice box, distribution tank, distribution channels, and lagoons) at varying levels of increased influent. • Stage levels in mixing box and sluice box. • Stop log levels and elevation levels in treatment cells. • Logs of high flow alarms and levels from the data historian. • Operational statistics (flow, temperature, lime content, etc.). • Flow measurements in and out of lagoon series. The evaluation of physical capacity will rely on a combination of this information and the observations and institutional knowledge of operators. If, at any time, the automated monitoring system (e.g., continued high alarms) or operator indicates a potential failure of system infrastructure, the Stress Test will immediately be stopped, and a stop work will be instituted to evaluate the system. After the test is stopped, influent flow will be reduced to routine levels, and the system will be inspected by operators before resuming routine operations. Source of Additional Information: • Appendix B.1 of the Draft Final BPSOU Capture and Treatment System Performance Evaluation Scoping Document (Atlantic Richfield, 2020a).	Types of information that are needed: Operational and monitoring information collected as part of routine BTL operations will be the primary source of information used to answer the estimation problem. Types of information include the following: • Operational monitoring data from BTL (flow, temperature, pH, lime dosing rate, etc.). • Historical BTL and BPSOU subdrain flow and operational data. • Influent, intermediate, and effluent analyte concentrations at variable time steps. • Selected influent chemical profile. • Influent and effluent flow rates. • PCP and TPH field kit results. • Analytical water quality samples from observation wells and Silver Bow Creek. • System water surface elevations (automated) and treatment lagoons series flow measurements for residence time estimation. • Information from the PHREEQC geochemical model of the system. Source of Additional Information: • Appendix B.1 of the Draft Final BPSOU Capture and Treatment System Performance Evaluation Scoping Document (Atlantic Richfield, 2020a). Applicable Limits/Thresholds: • U.S. Environmental Protection Agency (EPA) BPSOU CD (EPA, 2020).	Types of information that are needed: Field and laboratory data collected before, during, and after the pumping period from the augmented influent pumping wells will be the primary source of data. Information collected to support this evaluation will include the following: • Analytical water quality data collected from the additional pumping wells (to be installed). • Field water quality parameters collected at intervals specified by Table 4 (or at the discretion of the CPM and Contractor QAO. • Groundwater surface elevations at each pumping well and the monitoring network shown in Table 4. • Pumping flow rates from each pumping well. • Results from PCP and hydrocarbon field test kits. • Usable groundwater or surface water data from previous work (e.g., the BRW Phase II pumping tests). Source of Additional Information: • Northside Tailings/East Buffalo Gulch Area (NST) and DE Characterization and Geotechnical Investigation Sampling and Analysis Plan (Atlantic Richfield, 2018). • BRW Phase II QAPP (Atlantic Richfield, 2020b).
Step 4: Define the Boundaries of the Study: *The purpose of this step is to define the spatial and temporal boundaries of the study.*		
Specific Spatial Boundaries, Temporal Boundaries, and Other Practical Constraints: The BTL Site is the location of the Stress Test and is shown on Figure 2. The Stress Test will involve pumping additional water from within BPSOU to BTL for approximately 6-8 weeks, or as determined by the CPM and Contractor QAO. During test flow increases, the lagoon cell elevations will remain between the low and high safe operating levels (Atlantic Richfield, 2016).	Specific Spatial Boundaries, Temporal Boundaries, and Other Practical Constraints: The BTL Site is the location of the Stress Test and is shown on Figure 2. The Stress Test will involve pumping additional water from within BPSOU to BTL for a duration of approximately 6-8 weeks, or as determined by the CPM and Contractor QAO. The piping network for the additional sources of impacted water will be routed to BTL prior to the beginning of the Stress Test. Discharge from BTL is required to meet water quality criteria as prescribed in the BPSOU CD (EPA, 2020). During the Stress Test, alternative discharge standards have been proposed and are listed in Table 1.	Specific Spatial Boundaries, Temporal Boundaries, and Other Practical Constraints: Additional influent sources are located within the BPSOU; pumping will be from 7 discrete sources. This study objective is concerned with the aquifer behavior in areas experiencing extended pumping to provide additional influent for the Stress Test, including BRW and NST/DE. Groundwater level data will continue to be collected as long as the pumps are running, which is anticipated to be up to 8 weeks.
General Spatial Boundaries, Temporal Boundaries, and Other Practical Constraints: Fieldwork will begin once Agency approval has been received and is anticipated to take approximately 20 weeks total (the 20 week estimate includes an additional period of baseline monitoring prior to the stress test). A proposed schedule is shown on Figure 14. Potential constraints that could delay fieldwork include adverse weather conditions, challenges with Site conditions, breakdowns or unplanned maintenance, or other unforeseen issues. Major project delays resulting from these constraints will be recorded in the field logbooks and reported to the Agencies.		

<table>
<tr><th>1. BTL Physical Capacity Evaluation</th><th>2. BTL Chemical Breakthrough Evaluation</th><th>3. Additional Groundwater Source Monitoring</th></tr>
<tr><td>Estimation Problem</td><td>Estimation Problem</td><td>Estimation Problem</td></tr>
<tr><td colspan="3">Step 5: Develop the Analytical Approach: The purpose of this step is to specify the appropriate population parameters for making estimates.</td></tr>
<tr><td>Determining the physical capacity of the BTL system will depend greatly on careful observation by operators. Unlike the second DQO (BTL Chemical Breakthrough Evaluation), the study questions do not aim to increase flows to the physical breaking point, but rather to examine the condition of system components after a prolonged period of elevated influent flow. By decreasing system residence time and having a supplemental discharge line in place, high flows during the test will not increase the lagoon cell elevations above safe operating levels. Physical limitations to the system must be carefully evaluated to eliminate the chance of component failure while still determining capacity. At any time during the Stress Test, the test may be halted for safety considerations. Human health and environmental safety are paramount to the project, and at no time will the Stress Test jeopardize safety for the sake of data. Physical evaluation of the Stress Test will rely on the following:
• Water surface elevations or flows remaining below the high alarm setpoint (safe operating elevation) of any limiting physical elements (e.g., lagoon cells or mixing tank), as described in the BTL OM&M Manual (Atlantic Richfield, 2016) and the System Shakedown Plan Completion Report (Atlantic Richfield, 2014). A complete list of BTL system alarms is in Appendix C.
• Routine monitoring and observation of the system physical components (e.g., internal dikes or sluice box supports).
• Frequent monitoring and maintenance of all active physical components including pumps, the screw conveyor, mixing tanks, compressors, and any other equipment determined necessary to operational success.
• Increased cleaning of the mixing tank and sluice box, as determined by BTL operators and the CPM.
• Installation of alternate supplemental discharge line from the A3 effluent, as required to remain within safe operating elevations.

At the end of the Stress Test, all physical components will be assessed for any additional wear or weaknesses that may not have been observable during the test and all assessments noted before resuming routine operating conditions. Cleaning will occur more frequently during the test to eliminate increased lime or sludge buildup; cleaning will be noted in logbooks to correlate with any measured changes in flow or stage.</td>
<td>The Stress Test will rely on real-time monitoring data, analytical laboratory data, field analysis of select analytes, geochemical modeling data, and operator observations. The Stress Test is designed to determine the upper flow threshold of successful treatment at BTL; as such, influent flow is anticipated to be elevated to the point of chemical breakthrough. Physical limitations to the system must be carefully evaluated to eliminate the chance of component failure while still determining chemical capacity. At any time during the Stress Test, the test may be halted for safety considerations. Human health and environmental safety are paramount to the project, and at no time will the Stress Test jeopardize safety for the sake of data. The chemical evaluation will rely on the following:
• Historical routine effluent contaminant of concern (COC) concentrations and observed effluent concentrations.
• Historical routine influent COC concentrations and observed influent concentrations.
• Observed analyte specific mass removal and historical removal rates.
• Historical and observed in-stream water quality.
• Temporal trends in water quality parameters and intermediate water chemistry.
• Geochemical model assessment of governing chemical processes, focusing on mineral thermodynamics to track calcite precipitate and adsorption of dissolved contaminants.

In addition to routine sampling at stations INF-04 and EFS-07, operators will take daily samples from near the effluent of treatment cells A1, B1, C1, A2, B2, and C2 to collect field parameters and determine concentrations of total recoverable copper using a field measurement device (Figure 13), or at any other location deemed relevant during the Stress Test, as determined by the CPM and/or QAO. Operators will collect flow measurements weekly during each flow step at lagoon outlet structures to aid in calculating treatment residence time. If field-measured metal concentrations are above discharge criteria concentrations in the intermediate locations, an opportunity grab sample will be collected from the intermediate monitoring locations, INF-04 and EFS-07, and submitted for rush laboratory analysis. Surface water quality sampling will be conducted in Silver Bow Creek concurrent with effluent sampling to ensure continued protection of in-stream water quality during the test.

The Stress Test will consist of 3 flow steps that increase the magnitude of BTL influent (and reduce available treatment residence time). The first 2 steps will be similar in magnitude but provide different chemical data that may potentially simulate future additional flow from hydraulic control in BRW and Blacktail Creek, while the third flow step will target identification of treatment capacity. Each step will continue at least until the point of steady-state treatment conditions (daily field pH and field copper concentrations within 10% for 3 consecutive days [log standard units for pH or mass-volume concentration for copper]). The first and second step will continue for a minimum of 2 weeks and up to 3 weeks. The second step will continue for a minimum of 10 days or when chemical breakthrough occurs (Step 6). If the steady-state condition threshold cannot be met during any step after 3 weeks, it will be determined by a combination of residence time stability, evaluation of water quality trends, and insight from the operations team, in consultation with the CPM and QAO.</td>
<td>Additional groundwater source monitoring will use many of the same methods and procedures noted in the BRW Phase II QAPP (Atlantic Richfield, 2020b) regarding the performance of pumping tests. At the additional proposed pumping well locations, additional chemical and physical data will add resolution to data collected under previous pumping tests, and the extended period of pumping may reveal aquifer behavior not observed in previous 72-hour tests. The interaction between pumping wells at BRW and DE will more closely resemble the aquifer response under anticipated construction dewatering, and time-drawdown data from these locations may be useful for remedial design. The collected data may be used to:
• Estimate aquifer hydraulic characteristics in the areas experiencing pumping and compare the estimations to previous efforts.
• Evaluate whether the addition of pumping wells or extended pumping results in increased understanding of aquifer properties.
• Address any outstanding data gaps remaining from previous investigations.
• Determine whether specific controls may need to be developed for hydrocarbon or PCP removal during construction dewatering (Appendix D).

Groundwater elevation data collected using pressure transducers will have sufficient temporal resolution to capture groundwater response and create revised estimates of hydraulic properties of the aquifers. All elevation data will be collected according to Pioneer Standard Operating Procedures (SOPs) (Appendix A).

Groundwater analytical chemistry data collected from the additional pumping wells will follow relevant Pioneer SOPs (Appendix A) and include all required quality assurance and control sampling procedures outlined in Section 8.0 of the QAPP.</td></tr>
<tr><td colspan="3"><u>Quantity and Quality of Water Parameters:</u> The quantity of water moving through BTL during the Stress Test will be estimated using existing influent and effluent flow meters at the Site. The quality of water will be measured by collecting samples as indicated in Section 6.0 and Table 4 in the Stress Test QAPP.

<u>Appropriate Sampling and Analysis Methods:</u> Sampling and analysis methods are listed in Table 6. All laboratory results will go through a Level II validation as described in Section 8.0. Samples will be collected according to the Pioneer SOPs (Appendix A).</td></tr>
</table>

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<tr><td colspan="3">Step 6: Specify Performance or Acceptance Criteria: The purpose of this step is to define the performance or acceptance criteria that the collected data will need to achieve.</td></tr>
<tr><td>Numerical data used in the physical evaluation are limited to measured influent and effluent flow rates and stage data at various system locations. All measurement devices for flow and stage will be checked for accuracy and/or calibration prior to the beginning of the Stress Test.

Physical test failure will occur when one or more system components (e.g., mixing tank or lagoon cells) exceed the high alarm elevation or flow setpoint for two or more consecutive days (Appendix C), or when the BTL Lead Operator, Field Team Leader, and CPM determine a potential safety hazard resulting from high-flow operations.</td><td>The chemical breakthrough evaluation will include analysis of influent, mid-treatment, and effluent water quality using a variety of methods and devices. All water quality sample collection will follow SOPs (Appendix A). Field measurement of water quality parameters will follow routine procedures by BTL operators and follow all safety guidelines. Laboratory analytical water samples will be processed in adherence to EPA Contract Laboratory Program (CLP) laboratory SOPs, and follow all methods required to ensure Level 2 data validation.

Flow will be increased according to the steps described above and in Section 4.1 of the QAPP. Example thresholds that would result in termination of the step, or stopping the test due to potential chemical breakthrough, include the following:
Concentrations of field copper at A1, B1, or C1 exceed discharge standards for two consecutive days.
An effluent or intermediate opportunity water quality sample returns concentrations of any criteria analyte above the discharge standards.
The CPM, Field Team Leader, and QAO may decide to cease pumping at any time during the Stress Test pumping activities. Collection of routine data at the intermediate sample locations prior to the beginning of pumping will help develop appropriate shutdown criteria (Table 5). Indications of treatment breakthrough from analytical sample data, field sampling, operational data, and professional judgment may all inform the decision to cease pumping, in addition to the example criteria listed above.

An additional shutdown threshold may be determined if concentrations of TPH begin increasing in BRW pumping well production water, or if PCP concentrations are observed within select wells as noted in the sampling logic in Appendix D.</td><td>Measurement of groundwater elevation at augmented influent pumping wells will be by unvented pressure transducers. One transducer will be set up to record atmospheric pressure at BPSOU to use for pressure compensation during the data production. As noted in Step 5, transducer recording intervals will be frequent enough to capture the initial aquifer response to pumping and may then be reprogrammed to a larger interval during extended steady-state pumping conditions. Manual water levels will be recorded at the time of installation, and at any point when the transducers are downloaded or reprogrammed to correct measurement drift.

Water quality samples collected from the additional pumping wells for the second DQO will be subjected to Level II data validation and review and may be usable as additional screening data for remedial action design. Field PCP and TPH data may be used to advise project managers but will not be considered design quality data.

Sampling Design Errors and Acceptance Criteria: Potential error is inherent to any sampling design. To avoid expected or common errors, the following sampling and measurement acceptance criteria will be instituted for the pumping test:
Pre-test data collection must adequately quantify natural variability and trends by measuring water levels for at least 3 days before the Stress Test.
The measured length of open slotted screen must be plus or minus 0.1 feet to avoid error in calculations involving the screen length.
The difference between manual and transducer measured water levels must be less than the transducer accuracy or less than 80% of the fluctuation observed at the monitoring point; otherwise, the data may be rejected.</td></tr>
<tr><td colspan="3">The results of the Stress Test are anticipated to provide confirmable evidence of the upper limit of physical or chemical capacity at BTL, as outlined in Step 5 (e.g., decrease in contaminant removal rates). The performance criteria are anticipated to fall into one of three categories based on effluent water quality:

Scenario 1: There is no significant difference observed between effluent analyte concentrations at increasingly high flow and effluent analyte concentrations at routine flows.
Scenario 2: Effluent analyte concentrations show an increasing trend at increasingly high flow and/or may increase to above effluent discharge standards.
Scenario 3: Effluent analyte concentrations show a decreasing trend at increasingly high flow.

Removal of criteria analytes will be compared to historical mean removal to determine whether removal rate populations are in a significantly different group under the test conditions using statistical methods (e.g., analysis of variance).

<u>Sampling Design Errors and Acceptance Criteria:</u> Potential error is inherent to any sampling design. To avoid expected or common errors, the following sampling and measurement acceptance criteria will be instituted for the BTL Stress Test:
Flow measurement devices (to be installed) will be checked for accuracy and calibrated prior to the Stress Test work.
Requisite quality assurance/control water quality sampling will be instituted according to Section 8.0.
Sampling procedures will adhere to relevant SOPs (Appendix A).
<u>General Performance or Acceptance Criteria:</u> For estimation problems (Step 6A of EPA guidance), the collected data will be used to determine unknown parameters (e.g., high flow treatment capacity), together with some reported measure of uncertainty in the estimate. Errors occur when data mislead the site managers into choosing an inappropriate response or conclusion. The potential for errors exists because all field and analytical measurements inherently contain sampling error and/or measurement error. Error will be minimized for the BTL Stress Test evaluations by following all relevant procedures and guidance related to measurement and sampling design. Net cumulative error may be quantified using the root mean square method (Harmel et. al., 2006) to filter out real changes in operational metrics versus random error.

All analytical data gathered during the BTL Stress Test will be validated to ensure that the data are suitable for their intended purpose. Specific data validation processes that will be followed to ensure analytical results are within acceptable limits are detailed in Section 7.0 of the QAPP (Level II validation). The data validation process will include evaluating analytical control limits and the precision, accuracy, representativeness, comparability, and completeness parameters. If significant issues with the data are found, results will be discussed with the EPA.</td></tr>
</table>

1. BTL Physical Capacity Evaluation	2. BTL Chemical Breakthrough Evaluation	3. Additional Groundwater Source Monitoring
Estimation Problem	*Estimation Problem*	*Estimation Problem*
Step 7: Develop the Plan for Obtaining the Data*: This step identifies a resource-effective data collection design for generating data expected to satisfy the DQOs.*		
Section 4.0 of the QAPP outlines the sampling design and data collection procedures required to perform the physical capacity evaluation. Pre-test activities are outlined in Section 4.2, including all maintenance, cleaning, and calibration required to ensure minimal disruption of treatment flow and measurement. Flow data will be stored on the BTL data historian and retrieved following procedures outlined in Section 9. Flow measurement locations are shown on Figure 13. Manual measurements of stage and photographs will be recorded and stored according to Section 9.0. No additional data collection efforts beyond those mentioned in the QAPP are required to answer the study questions in Step 2.	Section 4.0 of the QAPP outlines the sampling design and data collection procedures required to perform the chemical breakthrough evaluation. Water quality sampling locations, frequency, and type are listed in Table 4. Water quality samples will be collected and analyzed according to the procedures and methods detailed in Table 6. Monitoring of flow and intermediate chemistry is described in Section 6.0. Sample frequency, location, flow rates, and other test details are subject to modification by the CPM and Contractor QAO as necessary to ensure test success. No additional data collection efforts beyond those mentioned in the QAPP are anticipated to answer the study questions in Step 2, however additional data collection needs may be identified during the field work. Section 2.3.1 of the QAPP outlines the alternate standards that will apply during the Stress Test. The potential use of alternate standards is identified in the BPSOU CD (EPA, 2020), but are not specifically defined, and must be approved by the Agencies.	The data collection for the additional groundwater monitoring effort is outlined in Section 4.0, including the installation of the groundwater level monitoring network and water quality sampling associated with the BTL chemical breakthrough DQO. Monitoring locations used in the evaluation are shown on Figure 11 and Figure 12, and sample collection is outlined in Table 4. Collection, analysis, and data storage for the evaluation will follow the procedures in the QAPP; screening level data and Level II analytical data validation may be used for remedial design efforts as determined by the Project Manager in conjunction with the Agencies.

References:

Atlantic Richfield, 2020a. Draft Final Capture and Treatment System Performance Evaluation Scoping Document. Atlantic Richfield Company. October 2020.

Atlantic Richfield, 2020b. Final Revised BRW Smelter Area Mine Waste Remediation and Contaminated Groundwater Hydraulic Control Site Phase II Quality Assurance Project Plan (QAPP). Atlantic Richfield Company. June 2020.

Atlantic Richfield, 2018. Draft Final Northside Tailings/East Buffalo Gulch Area (NST) and Diggings East Stormwater Basin Area (DE) Fill Characterization and Geotechnical Investigation Sampling and Analysis Plan (SAP). Atlantic Richfield Company. November 15, 2018.

Atlantic Richfield, 2016. Draft Final Butte Treatment Lagoons (BTL) Groundwater Treatment System Routine Operations, Maintenance, and Monitoring (OM&M) Plan. Atlantic Richfield Company. May 27, 2016.

Atlantic Richfield, 2014. Final Systems Control Document for the Butte Treatment Lagoons (BTL) at Lower Area One (LAO) Treatment System. Atlantic Richfield Company. November 19, 2014.

EPA, 2020. Consent Decree for the Butte Priority Soils Operable Unit. Partial Remedial Design/Remedial Action and Operation and Maintenance. U.S. Environmental Protection Agency. Available at https://www.co.silverbow.mt.us/2161/Butte-Priority-Soils-Operable-Unit-Conse.

Harmel, R. D., Cooper, R. J., Slade, R. M., Haney, R. L., and Arnold J. G., 2006., Cumulative Uncertainty in Measured Streamflow and Water Quality Data for Small Watersheds. May 2006.

Table 4. Stress Test Sampling Details and Objectives

Location	Investigation Purpose	Flow or Stage Measurement	*Frequency*	Transducer (Y/N)	*Frequency*	Water Quality (Analytical Group From Table 6)	*Frequency*
Existing Pumping Wells							
BRW-PW-01A	AI	Flow	15-minute automated	Y	15-minute	1, 3, 4, 7, 8	Daily-Weekly (Appendix D)
BRW-PW-01B	AI	Flow	15-minute automated	Y	15-minute	1, 3, 4, 7, 8	Daily-Weekly (Appendix D)
DE-PW-01	AI	Flow	15-minute automated	Y	15-minute	-	-
NST-PW-02	AI	Flow	15-minute automated	Y	15-minute	-	-
WCP-1	AI	Flow	15-minute automated	Y	15-minute	-	-
Proposed Pumping Wells							
BRW-PW-02	AI, GM	Flow	15-minute automated	Y	15-minute	1, 3, 4, 5a, 5b, 6, 7, 8	Daily-Weekly (Appendix D)
BTC-PW-01	AI, GM	Flow	15-minute automated	Y	15-minute	1, 5a, 5b, 6	Start/end of pumping
DE-PW-02	AI, GM	Flow	15-minute automated	Y	15-minute	1, 5a, 5b, 6	Start/end of pumping
BTL Locations							
HCC-01A	BA	Stage	Daily	Y	15-minute	1, 5a, 5b, 6	Group 1 daily, remainder prior to test
BRW-00	BA	Stage	Weekly	Existing	15-minute	1	Weekly
BRW-01W	BA	Stage	Weekly	Y	15-minute	1	Weekly
INF-04	BA	Flow	Automated	N	-	1, 5a	Group 1 daily, Group 5a weekly
A1	BA	Stage/Flow	Daily/Weekly	N	-	1,2	Daily
B1	BA	Stage	Daily	N	-	1,2	Daily
C1	BA	Stage	Daily	N	-	1,2	Daily
A2	BA	Stage	Daily	N	-	1,2	Daily
B2	BA	Stage	Daily	N	-	1,2	Daily
C2	BA	Stage	Daily	N	-	1,2	Daily
A3	BA	Stage/Flow	Daily/Weekly	N	-	1	Daily
B3	BA	Stage/Flow	Daily/Weekly	N	-	1	Daily
C3	BA	Stage/Flow	Daily/Weekly	N	-	1	Daily
EFS-07	BA	Flow	Automated	N	-	1, 5a, 5b	Group 1 daily, Group 5a twice per week, Group 5b rush weekly
SS-06G	BA	Flow	Automated	Existing	15-minute	1, 5c	Group 1 and Group 5c twice per week at same time as EFS-07 routine sampling.
SS-07	BA	Flow	Automated	Existing	-	1, 5c	Group 1 and Group 5c twice per week at same time as EFS-07 routine sampling.
Groundwater Elevation Monitoring							
BRW21-PZ51	GR	-	-	Y	15-minute	-	-
BRW21-PZ52	GR	-	-	Y	15-minute	-	-
BRW19-PZ46	GR	-	-	Y	15-minute	-	-
BRW19-PZ28	GR	-	-	Y	15-minute	-	-
BRW19-PZ29	GR	-	-	Y	15-minute	-	-
BRW19-PZ30	GR	-	-	Y	15-minute	-	-
BRW19-PZ40	GR	-	-	Y	15-minute	-	-
BRW19-PZ10D	GR	-	-	Y	15-minute	-	-
BRW19-PZ41	GR	-	-	Y	15-minute	-	-
BRW19-PZ45	GR	-	-	Y	15-minute	-	-
DE-PZ-10A/B	GR	-	-	Y	15-minute	-	-
DE-PZ-11A/B	GR	-	-	Y	15-minute	-	-
DE-PZ-15A/B	GR	-	-	Y	15-minute	-	-
BPS11-14A/B	GR	-	-	Y	15-minute	-	-
DE-PZ-03	GR	-	-	Y	15-minute	-	-
NST-PZ-07	GR	-	-	Y	15-minute	-	-
NST-PZ-03	GR	-	-	Y	15-minute	-	-
PCP Early Detection Monitoring[1]							
MW-I-96	ED	-		Y	15-minute	1, 4, 8	Daily-Weekly (Appendix D)
MW-O-01	ED	-		Y	15-minute	1, 4, 8	Daily-Weekly (Appendix D)
GS-13	ED	-		Y	15-minute	1, 4, 8	Daily-Weekly (Appendix D)
GS-17	ED	-		Y	15-minute	1, 4, 8	Daily-Weekly (Appendix D)
BRW21-PZ51	ED	-		Y	15-minute	1, 4, 8	Daily-Weekly (Appendix D)
BRW21-PZ52	ED	-		Y	15-minute	1, 4, 8	Daily-Weekly (Appendix D)
BRW19-PZ46	ED	-		Y	15-minute	1, 4, 8	Daily-Weekly (Appendix D)
BRW19-PZ01S	ED	-		Y	15-minute	1, 4, 8	Daily-Weekly (Appendix D)

[1]The final selection of locations to be included in the early detection monitoring will depend on property access, and the configuration of sampling will adjust accordingly. Additional locations may be added by the PM and/or Field Team Leater, if appropriate.

Table 4. Stress Test Sampling Details and Objectives

Location	Investigation Purpose	Flow or Stage Measurement	*Frequency*	Transducer (Y/N)	*Frequency*	Water Quality (Analytical Group From Table 6)	*Frequency*
Quality Assurance Samples							
Field Duplicate	Verify sampling procedures	-	-	-	-	5a, 5b, 5c, 6, 7, 8	1 per 20 samples
Equipment Blank	Verify equipment decontamination procedures	-	-	-	-	5a, 5b, 5c, 6, 7, 8	1 per 20 samples, as needed
Field Blank	Verify DI water concentrations	-	-	-	-	5a, 5b, 5c, 6, 7, 8	1 per 20 samples
Field Kit QA	Verify field kit methods	-	-	-	-	2, 3, 4	Per manufacturer recommendation

Investigation Purpose Key	
Abbreviation	**Definition**
AI	Augemented Influent
GM	Geochemical Modeling
BA	Breakthrough Assesssment
GR	Groundwater Response
ED	Early Detection

Table 5: Intermediate Sampling Test Suspension Logic

Test Phase	Frequency	Location	[a]Dissolved copper Field Concentration is:	Then...	Logic
Baseline	**Up to 8 Weekly Samples Prior to Test**	**A1, B1, C1, A2, B2, C2**	Any	Use the observed dissolved concentrations of field copper during normal operations to determine appropriate baseline values for comparison during increasing flows.	Field measured copper concentrations will be a good indicator of general trends in all COC analyte concentrations. Paired analytical samples during baseline sampling will indicate general levels of COCs in all intermediate locations during routine flows and optimum treatment conditions at BTL.
Pumping	**Daily**	**A1, B1, C1**	No increasing trend as per Mann-Kendall assessment at 95% confidence (n ≥ 6)	Note in logbook and continue pumping.	If concentrations of field detected copper remain near routine concentrations during periods of increased flow, treatment kinetics and dose rate are successfully adjusting to the increasing load. Daily field parameters and field measured iron and zinc should support the copper results in indicating successful treatment.
			Increasing trends per Mann-Kendall assessment at 95% confidence (n ≥ 6)	Note in logbook and notify CPM and QAO.	Increasing field copper concentrations per the Mann-Kendall test may indicate faltering treatment due to increased flow. Additional frequency of testing and comparison with observed trends in other collected data (e.g., pH, turbidity, and other metal analytes) will indicate further increases, stabilization, or a return to routine concentrations. Collection of samples at the 2-Cells (A2, B2, and C2) will indicate whether the lapse in treatment is propagating 'downstream'. Collection of field samples will continue at the 1-Cells to help characterize treatment kinetics and determine possible upgrades.
		A2, B2, C2	No increasing trend as per Mann-Kendall assessment at 95% confidence (n ≥ 6)	Note in logbook and continue pumping.	If 2-Cells remain at routine concentrations when concentrations in the 1-Cells are increasing, it is possible that decreased residency in the 1-Cells is shifting treatment 'downstream' but continuing to meet required reductions in COCs, or increased copper load at the 1-Cells has not yet reached the 2-Cells at the time of testing. Testing the 2-Cells will help identify any treatment shift and the spatial and temporal trends associated with increasing concentrations. Field water quality parameters will be measured at the 2-Cells as per routine operations, and additional field testing for other analytes may be performed as necessary.
			Increasing trends per Mann-Kendall assessment at 95% confidence (n ≥ 6)	Note in logbook, compare to 1-Cell results, notify CPM and QAO, and continue pumping.	If concentrations of field detected copper are elevated in both the 1-Cells and the 2-Cells, it may be an indication that changes in treatment resulting from sustained high flow are propagating 'downstream'. Continued frequent measurement of the 1-Cells and 2-Cells should indicate whether concentrations are stabilizing, or continuing to increase. If concentrations are elevated in the 2-Cells but at routine levels in the 1-Cells, continued observation will determine whether it is a data anomaly, indication of return to routine treatment efficacy, or another unknown phenomenon resulting from sustained high flow.
			Increasing trends per Mann-Kendall assessment at 95% confidence (n ≥ 6) and twice baseline sampling average concentration	Note in logbook, compare to 1-Cell results, notify CPM and QAO, and continue pumping. Sampling frequency will be increased to twice daily (start and end of shift).	Field copper concentrations above this threshold may indicate impending treatment breakthrough, and more frequent monitoring is warranted. Increasing trends may mean concentrations still remain at relatively low concentrations; twice the baseline concentration, though still below the standard, indicates a significant increase in dissolved copper. Comparison with observed trends in other collected data will contextualize further increases, stabilization, or a return to routine concentrations. Additional frequency of field sampling or analytical samples may be collected at this threshold as determined by the Field Team Leader in consultation with the CPM and QAO.
	Twice Daily	**B2, C2**	Four day average greater than or equal to 29.3 µg/L (D)[b]	Note in logbook and notify CPM and QAO. Reroute flow from B3 and C3 into A2 instead of the effluent lines and continue twice daily sampling.	The B- and C-Series, when operated parallel to the A-Series, typically have shorter retention time, and may reach the test suspension criteria sooner than the A-Series. In order to prevent exceeding the discharge criteria in the effluent of either the B- or C-Series, the effluent may be re-routed to A2 to allow for additional retention and settling time prior to discharge (this is the typical winter treatment pathway). The field team will continue to collect twice daily samples at B2 and C2 to aid in trend evaluation.
		A2	**Four day average greater than or equal to 29.3 µg/L (D)[b]**	**A running four day average of A2 dissolved copper concentrations will be calculated to determine if concentrations are above the test suspension values for copper (Table 1), and if the average rises above this concentration, the test will be suspended.** Note in logbook, collect rush opportunity samples at each cell, the effluent (EFS-07) and creek locations (SS-06G and SS-07) and notify CPM and QAO of shutdown threshold results.	Field copper concentrations at the discharge of A2 above this value indicate a likely treatment breakthrough, and the potential for exceedance at the lagoon discharge. To avoid potential exceedances of discharge standards, the test will be shut down at this value. Continued routine sampling will characterize system recovery, and any necessary maintenance or mitigation strategies following the test will be identified and performed.
Post-Pumping/Recovery	**Daily (up to 14 days)**	**A1, B1, C1, A2, B2, C2**	Any	Daily data collection will continue after pumping to determine the rate BTL returns to routine treatment conditions. Daily sampling will continue for 14 days or until copper concentrations in all cells are within ±10% of baseline average concentrations for three consecutive days (whichever comes first).	Continued data collection when influent flow lowers to normal seasonal rates will illuminate a return to routine conditions, and inform system resiliency. Recovery data will allow operators to determine how quickly to return to regular operations, and identify any required maintenance or lingering effects of the sustained high flows.

[a]Field concentration threshold values may be adjusted subsequent results of baseline sampling, as determined by the CPM and QAO.

[b]This decision point is equal to the hardness-adjusted federal dissolved chronic aquatic copper standard prior to implementation of BLM standard (Table 1). A copper value of 29.3µg/L assumes a hardness of 400 mg/L.

Table 6. Sample Collection, Preservation, Holding Time, and Analysis

Company	Sample Group	Analyte	Analytical Method	CRQL	Holding Time	Container Size	Preservation[1]	Locations
Field Parameters								
Pioneer	1	Temperature Specific conductance (SC) Dissolved Oxygen (DO) pH Oxidation Reduction Potential (ORP) Turbidity	SOP-WFM-04 SOP-WFM-03 SOP-WFM-07 SOP-WFM-01 SOP-WFM-02 SOP-WFM-08	NA	NA	NA	NA	INF-04, EFS-07, A1, B1, C1, A2, B2, C2, HCC-01A, BRW-00 and BRW-01W ponds (routine); DE-PW-02 and BRW-PW-02 (at sample collection)
Field Kit Analytes								
Pioneer	2	Total Cu, Fe, Zn (*HACH Field Kit*)	Manufacturer Rec.	NA	NA	NA	NA	A1, B1, C1, A2, B2, C2
	3	TPH (*Hanby Test*)	Manufacturer Rec.					Appendix D Hydrocarbon Logic Locations
	4	PCP (*Modern Water RaPID Assay*)	Manufacturer Rec.					Appendix D Early Detection Locations
Laboratory Samples								
Pace Labs or equivalent	5a[2]	Total aluminum (Al) Total arsenic (As) Total cadmium (Cd) Total calcium (Ca) Total copper (Cu) Total iron (Fe) Total lead (Pb) Total magnesium (Mg) Total silver (Ag) Total uranium (U) Total zinc (Zn)	EPA 200.8	9.0 µg/L 1.0 µg/L 0.03 µg/L 1,100 µg/L 2.0 µg/L 20 µg/L 0.3 µg/L 1,100 µg/L 0.2 µg/L 0.2 µg/L 8.0 µg/L	6 Months	250-mL HDPE bottle	Nitric acid (HNO3)	*Routine BTL Samples*: INF-04, EFS-07
		Total mercury (Hg)	EPA 245.1	0.01 µg/L	28 Days	250mL glass	Nitric acid (HNO3)	
		Hardness (calculation)	SM 2340	1,100 µg/L	NA	NA		
Eurofins TestAmerica or equivalent	5b	Dissolved aluminum (Al) Dissolved arsenic (As) Dissolved cadmium (Cd) Dissolved calcium (Ca) Dissolved copper (Cu) Dissolved iron (Fe) Dissolved lead (Pb) Dissolved magnesium (Mg) Dissolved silver (Ag) Dissolved zinc (Zn)	EPA 200.8	40 µg/L 1.0 µg/L 0.25 µg/L 500 µg/L 2.0 µg/L 20 µg/L 0.3 µg/L 500 µg/L 0.2 µg/L 8.0 µg/L	6 Months	250-mL HDPE bottle	Nitric acid (HNO3)	*Twice per week BTL Samples (Rush TAT)*: EFS-07 *Opportunity BTL Samples (Rush TAT):* A1, B1, C1, A2, B2, C2
		Dissolved Hardness (calculation)	SM 2340	500 µg/L				
		Dissolved mercury (Hg)	EPA 1631	0.005 µg/L	28 Days			
Pace Labs or equivalent	5c[3]	Total and Dissolved aluminum (Al) Total and Dissolved arsenic (As) Total and Dissolved cadmium (Cd) Dissolved calcium (Ca) Total and Dissolved copper (Cu) Total and Dissolved Iron (Fe) Total and Dissolved Lead (Pb) Dissolved magnesium (Mg) Total and Dissolved molybedium (Mo) Total and Dissolved silver (Ag) Total and Dissolved zinc (Zn)	EPA 200.8	9.0 µg/L 1.0 µg/L 0.03 µg/L 1,100 µg/L 2.0 µg/L 20 µg/L 0.3 µg/L 1,100 µg/L 0.8 µg/L 0.2 µg/L 8.0 µg/L	6 Months	250-mL HDPE bottle	Nitric acid (HNO3)	*Weekly Surface Water Samples (Standard TAT)* *Opportunity Samples (Rush TAT)*
		Hardness (calculation)	SM 2340	1,100 µg/L	NA	NA		
		Total and Dissolved mercury (Hg)	EPA 1631	0.01 µg/L	28 Days	250-mL HDPE bottle	Hydrochloric Acid (Hcl)	
		Alkalinity (as $CaCO_3$)	SM 2320B	5,000 µg/L	14 Days	500-mL HDPE bottle	Raw	
		Total Dissolved/Suspended Solids (TDS/TSS)	SM 2540C/D	10mg/L / 2mg/L	7 Days			
		Total ammonia (NH_3 + NH_4 as N) Nitrogen (nitrate + nitrite)	EPA 350.1 EPA 353.2	500 µg/L 150 µg/L	28 days	250-mL HDPE bottle	H2SO4	
		Dissolved organic carbon	EPA 9060A	1,500 µg/L	28 days	250-mL amber glass bottle	Zero head space; H2SO4, field filtered with 0.45 µm filter	

Table 6. Sample Collection, Preservation, Holding Time, and Analysis

Company	Sample Group	Analyte	Analytical Method	CRQL	Holding Time	Container Size	Preservation[1]	Locations
Laboratory Samples Continued								
Eurofins TestAmerica or equivalent	6	Total and Dissolved barium (Ba)	EPA 200.8/EPA 200.7	1.2 µg/L	6 Months	250-mL HDPE bottle Acidified with nitric acid (HNO3), field filtered with 0.45 µm filter (dissolved fraction)	Nitric acid (HNO3), field filtered with 0.45 µm filter (dissolved fraction)	*Geochemical Model Samples (Groups 5a, 5b and 6):* HCC-01A, DE-PW-02, BRW-PW-02, BTC-PW-01, Opportunity Samples
		Total and Dissolved boron (B)		500 µg/L				
		Total and Dissolved calcium (Ca)		500 µg/L				
		Total and Dissolved chromium (Cr)		0.8 µg/L				
		Total and Dissolved lithium (Li)		100 µg/L				
		Total and Dissolved magnesium (Mg)		500 µg/L				
		Total and Dissolved manganese (Mn)		2.0 µg/L				
		Total and Dissolved potassium (K)		3,300 µg/L				
		Total and Dissolved selenium (Se)		8.0 µg/L				
		Total and Dissolved silica as SiO2		2,260 µg/L				
		Total and Dissolved sodium (Na)		500 µg/L				
		Total and Dissolved strontium (Sr)		0.4 µg/L				
		Total ammonia (NH_3 + NH_4 as N)	EPA 350.1	500 µg/L	28 days	250-mL HDPE bottle	H2SO4	
		Nitrate (NO2) and Nitrite (NO3)	EPA 353.2	150 µg/L				
		Total Phosphorus	EPA 365.1	250 µg/L				
		Sulfate (SO_4)	EPA 300.0	1,500 µg/L	28 Days	500-mL HDPE bottle	Raw	
		Fluoride (F-)		200 µg/L				
		Chloride (Cl-)		1,500 µg/L				
		Bromide (Br-)		1,000 µg/L				
		Alkalinity (as $CaCO_3$)	SM 2320B	5,000 µg/L	14 Days			
		Total Dissolved/Suspended Solids (TDS/TSS)	SM 2540C/D	10mg/L / 2mg/L	7 Days			
		Dissolved organic carbon	EPA 9060A	1,500 µg/L	28 days	250-mL amber glass bottle	Zero head space; H2SO4, field filtered with 0.45 µm filter (dissolved fraction)	
		Total organic carbon						
		Total carbon						
		Total inorganic carbon (Calculation)						
Eurofins TestAmerica or equivalent	7	Volatile Petroleum Hydrocarbons (VPH)	MAVPH (Rev 1.1)	Analyte Specific - Meets DEQ-7 Required Reporting Limit and/or DEQ Risk-Based Screening Level where applicable.	14 Days	3--- 40-mL clear glass VOA vials	Unfiltered, HCl.	*Confirmation samples per Appendix D:* BRW-PW-01A, BRW-PW-01B. BRW-PW-02
		EPH Fractionation with Polycyclic Aromatic Hydrocarbons (PAHs)	Montana Method EPH (PAHs: 8270C or 8270D)			2--- 1-L amber glass	Unfiltered, H2SO4.	
		Lead Scavengers (1, 2 dichloroethane and 1, 2 dibromoetheane)	EPA 8011, EPA 8260D			6--- 40-mL clear glass VOA vials	Unfiltered, HCl.	
	8	Polychlorinated biphenyls (PCB)	EPA 8082A	0.45 µg/L	1 year	2, 250 mL amber glass	Raw, cool ≤6°C	*Confirmation samples following logic in Appendix D, or as determined by Field Team Leader and CPM.*
		Pentachlorophenol (PCP)	EPA 8270E SIM	1 µg/L	7 days	2, 250 mL amber glass		
		2,3,4,6 Tetrachlorophenol	EPA 8270E	5 µg/L	7 days	2-1L amber glass		
		2,3,5,6-Tetrachlorophenol		0.6 µg/L				
		2,4,6-Trichlorophenol		0.6 µg/L				
		2,4-Dichlorophenol		1 µg/L				
		2-Chlorophenol		1 µg/L				
		2,3,7,8-TCDD	EPA 1613B	10.0 µg/L	1 year			
		2,3,7,8-TCDF		10.0 µg/L				
		1,2,3,7,8-PeCDD		50.0 µg/L				
		1,2,3,7,8-PeCDF		50.0 µg/L				
		2,3,4,7,8-PeCDF		50.0 µg/L				
		1,2,3,4,7,8-HxCDD		50.0 µg/L				
		1,2,3,6,7,8-HxCDD		50.0 µg/L				
		1,2,3,7,8,9-HxCDD		50.0 µg/L				
		1,2,3,4,7,8-HxCDF		50.0 µg/L				
		1,2,3,6,7,8-HxCDF		50.0 µg/L				
		1,2,3,7,8,9-HxCDF		50.0 µg/L				
		2,3,4,6,7,8-HxCDF		50.0 µg/L				
		1,2,3,4,6,7,8-HpCDD		50.0 µg/L				
		1,2,3,4,6,7,8-HpCDF		50.0 µg/L				
		1,2,3,4,7,8,9-HpCDF		50.0 µg/L				
		OCDD		100 µg/L				
		OCDF		100 µg/L				

[1]In addition to the preservation listed, all samples will be cooled to 4±2°C.

[2]Group 5a samples will be collected under Butte Treatment Lagoons (BTL) Operation, Maintenance, and Monitoring (OM&M) Plan for Butte Priority Soils Operable Unit (Atlantic Richfield, 2019)

[3]Group 5c samples collected under Final BPSOU Interim 2020/2021 Site-Wide Surface Water Monitoring QAPP Silver Bow Creek/Butte Area NPL Site (Atlantic Richfield, November 2020d)

NA - Not Applicable

Acronyms:

mL - milliliter, HDPE - High-density polyethylene, µm - micrometer, µg - microgram, mg - milligram

CRQL - contract required quantitation limit, MDL - method detection limit

Table 7: Precision, Accuracy, and Completeness Calculations

Characteristic	Formula	Symbols
Precision (as relative percent difference, RPD)	$RPD = \frac{(x_i - x_j)}{\left(\frac{x_i + x_j}{2}\right)} \times 100$	x_i, x_j: replicate values of x
Precision (as relative standard deviation, RSD, otherwise known as coefficient of variation)	$RSD = \frac{\sigma}{\bar{x}} \times 100$	σ: sample standard deviation $\bar{x}$: sample mean
Accuracy (as percent recovery, R, for samples without a background level of the analyte, such as reference materials, laboratory control samples and performance evaluation samples)	$R = \frac{x}{t} \times 100$	x: sample value t: true or assumed value
Completeness (as a percentage, C)	$C = \frac{n}{N} \times 100$	n: number of valid data points produced N: total number of samples taken

Table 8: Sample Identification Scheme

Project Name	Sample Type	Location	Collection Date	QA/QC
BTL Stress Test: "ST"	"GW" = Groundwater "TW"= Treatment Water	• Use proposed or established nomenclature for selected groundwater sources, no dashes (e.g., "DEPW02")[a]. • Use BTL OM&M location name for BTL samples (e.g., "HCC01A")[b] • Retain "0" in all location names	• Use the following format for the date: July 15, 2021 would be 20210715 • Use a "0" placeholder for single digit months and days	• For a twin sample, append an end ID of "T" onto the location name (e.g., "DEPW02T"). • For equipment rinsate blanks, use an end ID of "R". • For field blanks, use an end ID of "F". • For opportunity samples, use the "OPP" signifier at the end of the name.

[a] Examples of sample-specific ID codes are presented below:

- An opportunity sample collected at location A1 in BTL on August 2, 2021 for submittal to Pace Labs will be: ST-TW-A1-20210802-OPP
- A groundwater characterization sample collected at BRW-PW-02 at the end of the stress test on August 25 will be named: ST-GW-BRWPW02-20210825

[b] All samples collected under routine BTL operations used for the stress test evaluation will follow the naming convention used for routine BTL samples outlined in the OM&M manual (Atlantic Richfield, 2016).

Appendix A
Pioneer Standard Operating Procedures (SOPs)

PURPOSE	To provide standard instructions for decontamination of all personnel leaving a contaminated area.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
1. Wash/ Remove outer contaminated items.	Remove nitrile or latex gloves by grasping the outside of the opposite glove near the wrist. Pull and peel the glove away from the hand, turning the glove inside out with the contaminated side now on the inside. Hold the removed glove in the opposite gloved hand. Slide one or two fingers of the ungloved hand under the wrist of the remaining glove. Peel glove off from the inside, creating a bag for both gloves. If wearing protective coveralls such as Tyvec suites, brush built up material off the suit, only if in designated decontamination zone. Unzip the coverall and begin rolling that outwards, rolling it down over your shoulders. Place both hands behind your back and pull down each arm until completely removed. Sit down and remove each shoe then roll the coveralls down (ensuring the contaminated side is not touched or comes into contact with clothing) over your knees until completely removed. If there is not a designated decontamination zone, remove personal protective equipment (PPE) carefully to contain material and place it in the appropriate disposal container. For instructions to remove additional PPE not described in this document, refer to the project's HASP. Wash with soap (nonphosphate) and tap water the outer, more heavily contaminated items, such as boots. Rinse the items in tap water.
2. Wash inner contaminated items.	If necessary, wash with soap (nonphosphate) and tap water the inner, less contaminated items. Rinse the items in tap water.
3. Store/ transport items.	Store/transport contaminated items in a separate designated area to prevent cross contamination prior to disposal.

4. Dispose of contaminated items.	Dispose of contaminated clothing and equipment in accordance with site/project, client, and/or federal and state requirements.
5. Contact the Safety and Health Manager.	For contaminants other than those found typically at uncontrolled hazardous waste sites, such as asbestos, PCB, PCE, etc. see the Safety and Health Manager.
Information about Emergency Decontamination	
1. During life-saving process.	If the decontamination procedure is essential to the life-saving process, decontamination must be performed immediately.
2. During heat-related illness.	If heat-related illness develops, protective clothing should be removed as soon as possible. Wash, rinse, and/or cut off protective clothing/equipment.
3. When medical treatment is needed.	If medical treatment is required to save a life, decontamination should be delayed until the victim is stabilized. Wrap the victim to reduce contamination of others. Alert medical personnel to the emergency and instruct them about potential contamination. Instruct medical personnel about specific decontamination procedures.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated items and resulting water from decontamination procedures.	Sites.	Inadvertent exposure to contaminated items and water resulting from decontamination procedures could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will follow decontamination procedures as described above. Employees will wear nitrile gloves and safety glasses when handling contaminated items.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Not applicable.			
GRAVITY	Slips and falls.	Areas designated for decontamination procedures.	Slips and falls could occur while performing decontamination procedures due to slippery surfaces resulting in bruises, scrapes, or broken bones.	Workers will wear work boots with good traction and ankle support. Keep work area as dry as possible. Wear muck boots as necessary.
WEATHER	Cold/heat stress. Hypothermia/frost bite.	Sites. Sites where air temperature is 35.6°F (2°C) or	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke. Workers whose clothing becomes wet	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Employees will change clothing, if it becomes wet.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
		less.	during decontamination procedures may be exposed to hypothermia and/or frostbite.	
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
			effects and/or property damage.	
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDS	Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	
TOOLS	In general, the following items will be needed: soap, tap water, tarps, decontamination tubs, brushes, and sprayers. The Sampling and Analysis Plan (SAP) or Quality Assurance Project Plan (QAPP) will describe additional items needed for decontamination.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**12/03/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**12/03/2014**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for equipment decontamination.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.
NOTES	All equipment leaving the contaminated area of a site must be decontaminated. Decontamination methods include removal of contaminants through physical, chemical, or a combination of both methods. Decontamination procedures are to be performed in the same level of protection used in the contaminated area of a site. In some cases, decontamination personnel may be sufficiently protected by wearing one level lower protection. The information for site specific equipment decontamination and personnel protection levels, as detailed in the Sampling and Analysis Plan (SAP), work plan (WP), and Site-Specific Health and Safety Plan (SSHASP), should be followed. The following decontamination procedures are for typical uncontrolled hazardous waste sites. For a specific or unusual contaminant, such as dioxins, see the SSHASP and consult with the Safety and Health Manager. Decontamination procedures should be used in conjunction with methods to prevent contamination of sampling and monitoring equipment. If practical, particularly with organic contaminants, one-time-use equipment should be used, and disposed of in accordance with the SAP, work plan, and SSHASP. This SOP covers all equipment decontamination EXCEPT for submersible pumps. Decontamination of pumps is detailed in SOP-DE-02A – Equipment Decontamination - Pumps for Well Sampling.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
1. Setup decontamination station.	Review the SAP or WP and determine if decontamination fluids need to be contained. If the fluids require containment, set up the decontamination station so that it is located within a small plastic swimming pool or on plastic sheeting with turned up edges to contain water that may slop over during the decontamination process. If pressurized or gravity flow water is available, attach a hose or piping to reach the decontamination area. If no water is available, four 5-gallon buckets can be used for cleaning most equipment. Label the buckets: gross wash; soap wash; DI rinse; final rinse. Lay out plastic or foil to place the cleaned equipment on to air dry.

	Pour approximately 2 ½ to 3 gallons of de-ionized (DI) water into each bucket. Add a **few** (1-3 drops) of Liquinox© soap to the bucket marked: soap wash.
2. Remove gross contamination.	Remove gross contamination using pressurized or gravity flow tap water, if available. If not, equipment will be scrubbed in the 5-gallon bucket of DI water marked: gross wash and a stiff brush (dedicated to the gross wash step).
3. Wash equipment.	Move the equipment to the 5-gallon bucket marked: soap wash. Wash equipment with a stiff brush (dedicated to the soap wash step).
4. Triple rinse equipment.	Triple rinse the equipment with DI water to remove any soap residue in the bucket marked: DI rinse.
5. Second Rinse with DI Water	Triple rinse the equipment again in the bucket marked: Final rinse.
6. Rinse equipment with chemicals.	In many cases, the tap water and de-ionized water rinses will be sufficient. If specified in the SAP, work plan, or SSHASP, chemical rinses of the equipment may be required. For inorganic contaminants, a mixture of 10:1 nitric acid in distilled water (10 parts water to 1 part nitric acid) is commonly used. A Methanol rinse may be required for some organic contaminants, such as hydrocarbons. Spray bottles, clearly marked with the appropriate chemical name, are an acceptable means of rinsing most equipment. To perform the chemical rinse, hold the equipment over a collection container (5-gallon bucket or bowl) spray the piece of equipment inside and out starting at the top and working down to the bottom. Make sure that all workers and vehicles are upwind of the spray. Dispose of the contained chemicals as described in the SAP, WP or SSHASP. The Safety and Health Manager and/or Project Manager must approve the disposal method used. If a chemical rinse is used, rinse the equipment again with DI water in a 5th bucket of DI water. This water will need to be retained (i.e., do not dispose of this water on site), tested, and disposed of according to federal and state requirements for the chemical used. The Safety and Health Manager and/or Project Manager must approve the disposal method used.
7. Air dry equipment.	Place equipment on plastic sheeting or foil to air dry.
8. Transport/ store equipment.	Wrap equipment in foil or plastic wrap to transport or store.
9. Triple rinse decontamination equipment.	Triple rinse equipment (i.e., brushes, buckets, tubs, etc.) used in the decontamination process with water, preferably pressurized.
10. Wash	Agitate the equipment used in the decontamination process in the soap/DI water

decontamination equipment.	solution.
11. Triple rinse decontamination equipment.	Triple rinse equipment with DI-water.
12. Store and label decontamination equipment.	Place equipment in appropriate areas, so they are used only for decontamination purposes. Label the equipment, if necessary.
13. Dispose of decontamination solutions.	When contaminants have been identified, either in the solutions or elsewhere on the site, solutions should be disposed of appropriately as discussed in the SAP, work plan, or SSHASP. If they are hazardous (e.g., characteristic, listed, etc.), dispose of them according to federal and state requirements. The Safety and Health Manager and/or Project Manager must approve the disposal method used. Note: when using other than the above mentioned solutions, check with the Safety and Health Manager and the Project Manager.
14. Measure effectiveness of procedures.	Effectiveness of the decontamination procedures will be measured using field equipment rinsate blanks (see the Site-Specific Quality Assurance Project Plan).

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated items and resulting water from decontamination procedures.	Sites.	Inadvertent exposure to contaminated items and water resulting from decontamination procedures could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will follow decontamination procedures as described above. Employees will wear nitrile gloves and safety glasses when handling contaminated items.
	Chemical rinse (e.g., dilute nitric acid, methanol, and hexane).	Sites.	Employees could be exposed to chemicals via ingestion and skin/eye contact when decontaminating equipment. Exposure could cause irritation of skin/eye and adverse health effects.	Check and follow safety procedures as outlined in the chemical-specific Safety Data Sheets. Employees will prevent skin/eye contact with chemicals and they will wear nitrile gloves and eye protection when handling chemicals. Employees will practice proper personal hygiene – wash hands prior to eating/drinking, after decontaminating equipment, and when leaving the site. All workers and vehicles will stand upwind when spraying equipment with chemicals. Refer to the Chemical Flushing Guidelines available inside vehicle's first aid kit for first-aid procedures in case of contact with chemicals.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Improper lifting.	Sites.	Back injuries and muscle/back strains could result when using	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not

HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

			improper techniques to lift and carry 5-gallon containers.	with back, and avoid lifting loads above shoulder's height. Two people will lift awkward/heavy tools and equipment.
GRAVITY	Falls from slips and trips.	Areas designated for decontamination procedures.	Slips and falls could occur while performing decontamination procedures due to slippery surfaces resulting in bruises, scrapes, or broken bones.	Workers will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Hypothermia/frost bite.	Sites where air temperature is 35.6°F (2°C) or less.	Workers whose clothing becomes wet during decontamination procedures may be exposed to hypothermia and/or frostbite.	Employees will change clothing, if it becomes wet.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Contact with hot surfaces.	Foil and decontamination equipment.	If foil and decontamination equipment are placed directly in the sun, they could get hot. Contact with hot surfaces could result in personal injury.	Personnel will prevent setting decontamination stations directly in the sun.
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDS	Safety Data Sheets (SDSs) for corresponding chemicals used during chemical rinse. Additional SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	
TOOLS	Five 5-gallon buckets, tap water, stiff brushes, soap, de-ionized or distilled water, chemicals for chemical rinse (if required), plastic sheeting or foil, tarps, and sprayers (if available). If additional items for decontamination are needed, they will be listed on the SAP.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**06/05/2015**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**06/05/2015**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for equipment decontamination to pumps for well sampling.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Notes	All non-disposable or non-dedicated equipment used for sampling or monitoring activities must be decontaminated prior to leaving a site. Decontamination methods include removal of contaminants through physical methods, chemical cleaning or a combination of both methods. Decontamination of equipment should be performed in the same level of protection as worn during sampling. In some cases, personnel may be sufficiently protected during decontamination activities by wearing one level lower of PPE. Requirements for site specific equipment decontamination and personnel protection levels as detailed in the sampling and analysis plan (SAP), work plan (WP) or Site-Specific Health and Safety Plan (HASP) should be followed. The following decontamination procedures are for typical uncontrolled hazardous waste sites. For a specific or unusual contaminant such as dioxins, the decontamination procedures should be discussed in the SAP, WP and or HASP. Decontamination procedures should be used in conjunction with storage methods that prevent contamination of cleaned sampling and monitoring equipment. One time use equipment is preferred if practical, and should be disposed of in accordance with the site-specific HASP, SAP or WP. Dedicated equipment should be used, when practical for long term sampling at a location. Prior to the sampling event review the HASP and SAP to determine if purge and decontamination water needs to be contained and and/or proper disposal and storage requirements. When preparing a SAP/HASP determine if water from all stages of the decontamination procedure needs to be contained or if only water from initial stages of the process requires containment. As part of the planning process in determining a method for storage and disposal of purge and decontamination fluids, the amount of water that could be generated during the sampling event, and the type and concentrations of potential contaminants should be estimated. If needed the proper equipment for either storage or disposal should be available on-site at the start of sampling. Water can be contained at the sampling location or on site in

	tanks, barrels or buckets for later disposal. Purge and decontamination water stored on the site can be sampled and analyzed so that the proper disposal method can be determined. Waste water could also be removed at the time of sampling with a pump truck to a disposal site.
Decontamination Procedures for Inorganic Contaminants	
1. Decontamination procedures for inorganic contaminants.	1. Set up the decontamination station. If water needs to be contained, place a sheet of plastic on the ground or a small swimming pool in the decontamination area. Wrap the edges of the plastic sheeting around pieces of PVC or boards to form a small pool to prevent any spilled water from running onto adjacent ground. All decontamination activities should take place within this confined area. If containment of decontamination fluids is required, set up a means of collecting the water (bucket, hose, barrel, etc.) 2. Remove pump from the well making sure that tubing and pump do not contact the ground surface. If disposable or dedicated tubing is being used, remove tubing from the pump and place in appropriate storage/refuse container. Don a new pair of gloves and if needed add a small piece of tubing to pump. 3. Place pump in decontamination container containing tap water. The size of the pump and amount of tubing needing decontamination will determine the size of the container. The container can range from a stainless steel pan which holds 1 -2 gallons for the smaller 12 volt submersible pumps with a small amount of tubing to a 5 gallon bucket or similar large container that will hold the larger pumps such as the Grunfoss Redi-Flo II and larger 12 volt submersible pumps . The pump should be placed in a container that is tall enough to submerge the pump, and is easy to pour additional fluid into. Non-dedicated tubing such as that on the Grunfoss Redi-Flo II will be decontaminated on the reel or for smaller amounts of reusable tubing typically found on the 12 volt submersible pumps, the tubing and electric cord will be coiled as it is removed from the well and placed in a bucket dedicated to decontamination. 4. If not done previously, don a new pair of nitrile gloves. 5. Pour tap water into the container to cover the pump. Turn the pump on and continue pouring tap water into the container until all water from the well has been flushed from the pump and tubing. The amount will depend on the amount of tubing associated with the pump and can range from 1 gallon for the smaller pumps to 5 gallons for the Grunfoss pumps. If the water purged from the well was turbid or colored, the water flowing from the pump discharge can be monitored to determine when the well water has been removed. If the water is to be contained, make sure it is discharged throughout the decontamination process into the appropriate container. 6. Add a **very** small pinch or drop of non-phosphate soap (use Liquinox© or Alconox©) to the container and turn on pump. Continue pouring tap water into the container to flush the pump until the soapy water has been pumped through the entire length of tubing.

	7. Turn the pump off and place it in a second container for a de-ionized (DI) water flush of the soapy water. Pour DI water into the container to cover the pump. Turn the pump on and continue pouring DI water into the container until the soapy water has been flushed from the system. This water should be discharged over any tubing that will be reinserted into the next well. Keep in mind that this process is to remove contaminants from the pump and tubing so that they are not introduced to the next well. Make sure that the tubing is thoroughly rinsed. Water purged from the next well will flush remaining DI water from the tubing. 8. Turn the pump off, empty water from the bucket containing tubing if necessary and place pump and tubing into a bucket dedicated for pump storage. The Grunfoss Redi-Flow II pump should be returned to the pump holder on the reel, remember to rinse the pump holder with DI water between wells. Care should be taken to keep tubing and pumps from touching the ground or other surface during transport and storage. A plastic bag can be placed over the container holding the pump or a dedicated plastic container can be used to transport or store the pump. 9. If containment is required, empty the water remaining in the decontamination containers into the storage/disposal container. Cover the dedicated decontamination containers with plastic, foil or a lid to prevent contaminants from entering the containers during transport or storage. Empty the water in the swimming pool or plastic into the storage container by scooping the water into the disposal container. If needed a funnel dedicated to the project can be used to help in getting water into the container.
Decontamination Procedures for Organic Contaminants	
1. Decontamination procedures for organic contaminants.	**It is strongly recommended that disposable or dedicated tubing be used for all organic contaminant sampling.** **If a submersible pump is required for sampling, a stainless steel pump that can be taken apart for cleaning is recommended.** **If free product is detected in a well, use disposable tubing or a bailer to collect the sample as purging large amounts of product through tubing makes it almost impossible to clean.** 1. Set up the decontamination station. If water needs to be contained, place a sheet of plastic on the ground or a small swimming pool in the decontamination area. Wrap the edges of the plastic sheeting around pieces of PVC or boards to form a small pool to prevent any spilled water from running onto adjacent ground. All decontamination activities should take place within this confined area. If containment of decontamination fluids is required, set up a means of collecting the water (bucket, hose, barrel, etc.). 2. Remove pump from the well making sure that tubing and pump do not contact the ground surface. If disposable or dedicated tubing is being used, remove

tubing from pump and place in appropriate storage/refuse container. Don a new pair of nitrile gloves. Wipe pump with a paper towel wetted with DI or methanol (or solvent specified in the SAP/WP/HASP). Add a small piece of tubing to pump. If tubing is to be reused, wet a paper towel with a small amount of DI or methanol (or other solvent specified in the SAP) and wipe pump and tubing as it is removed from the well.

3. Place pump in decontamination container containing tap water. The size of the pump and amount of tubing needing decontamination will determine the size of the container. The container can range from a stainless steel pan which holds 1 -2 gallons for the smaller 12 volt submersible pumps with a small amount of tubing to a 5 gallon bucket or similar large container that will hold the larger pumps such as the Grunfoss Redi-Flo II and the larger 12 volt submersible pumps. The pump should be placed in a container that is tall enough to submerge the pump, and is easy to pour additional fluid into. Non-dedicated tubing such as that on the Grunfoss Redi-Flo II will be decontaminated on the reel or for smaller amounts of reusable tubing on the 12 volt submersible pumps, the tubing and electric cord will be coiled as it is removed from the well and placed in a bucket dedicated to decontamination.

4. If not done previously, don a new pair of nitrile gloves.

5. Pour tap water into the container to cover the pump. Turn the pump on and continue pouring tap water into the container until all water from the well has been flushed from the pump and tubing. The amount will depend on the amount of tubing associated with the pump and can range from 1 gallon for the smaller pumps to 5 gallons for the Grunfoss pumps. If the water purged from the well was turbid or colored, the water flushing from the pump discharge can be monitored to determine when the well water has been removed. If the water is to be contained make sure it is discharged throughout the decontamination process into the appropriate container.

6. Add a **very** small pinch or drop of non-phosphate soap (use Liquinox© or Alconox©) to the container and turn on pump. Continue pouring tap water into the container to flush the pump until the soapy water has at least been pumped through the entire length of tubing.

7. At this time a small amount of methanol or solvent can be run through the pump, depending on the expected contaminants. Turn off the pump and place it into a container holding the appropriate solvent. Turn the pump on and run the solvent through the pump. Make sure that a container is available to catch and retain the used solvent. Turn the pump off.

8. If using a stainless steel pump that can be taken apart, follow the manufacturer's directions, dissemble the pump, wipe all parts of the pump with methanol, DI or other solvent and reassemble.

9. Place the pump in a container for a de-ionized (DI) water flush of the pump and tubing. Pour DI water into the container to cover the pump. Turn the pump on

	and continue pouring DI water into the container until the solvent (methanol) has been flushed from the system. This water should be discharged over any tubing that will be reinserted into the next well. Keep in mind that this process is to remove contaminants from the pump and tubing so that they are not introduced to the next well. Make sure that the tubing is thoroughly rinsed. Water from the next well will be run through the tubing prior to sampling, any DI water remaining will be flushed from the pump during the purging. 10. Turn the pump off, empty water from the bucket containing tubing if necessary and place pump and tubing into a bucket dedicated for pump storage. The Grunfoss Redi-Flow II pump should be returned to the pump holder on the reel, remember to rinse the pump holder with DI water between wells. Care should be taken to keep tubing and pumps from touching the ground or other surface during transport and storage. A plastic bag can be placed over the container holding the pump or a dedicated plastic container can be used to transport or store the pump. 11. If containment is required empty the water remaining in the decontamination containers into the storage/disposal container. Cover the dedicated decontamination containers with plastic, foil or a lid to prevent contaminants from entering the containers during transport or storage. Empty the water in the swimming pool or plastic into the storage container by scooping the water into the disposal container. If needed a funnel dedicated to the project can be used to help in getting water into the container
Equipment Used for Decontamination	
1. Equipment used for decontamination.	1. Rinse equipment used in the decontamination process with tap water, preferably pressurized. **Do not rinse the container labeled DI!** 2. Keep decontamination equipment separated so that it is only used for decontamination. Make sure it is labeled appropriately.
Disposal of Decontamination Solutions	
1. Disposal of decontamination solutions.	1. Dispose of the soap/tap water solution and the de-ionized water rinse as detailed in the SAP/WP or site specific HASP. 2. Dispose of the solvent rinse residue into proper waste containers. Be sure to check with the health and safety officer and the project manager for disposal requirements. For example, some solvents can be evaporated.
Effectiveness of Decontamination	
1. Effectiveness of decontamination.	1. Effectiveness of the decontamination procedures will be measured using field equipment rinsate blanks (see the site-specific Quality Assurance Project Plan and SOP-SA-03B Preparation of Equipment Rinsate Blanks for Submersible Pumps).

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated items and resulting water from decontamination procedures.	Sites.	Inadvertent exposure to contaminated items and water resulting from decontamination procedures could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking, after decontamination procedures, and when leaving the site. Employees will follow decontamination procedures as described above. Employees will wear nitrile gloves and safety glasses when handling contaminated items and decontaminating equipment.
	Methanol.	Sites.	Employees could be exposed to methanol via skin/eye contact and ingestion/ inhalation when decontaminating equipment. Exposure could cause irritation of skin/eye. Adverse health effects can also result if methanol is ingested and/or inhaled. Direct contact with methanol during winter months can result in skin discomfort due to rapid evaporative cooling.	Employees will prevent skin/eye contact with methanol and they will wear nitrile gloves and safety glasses when handling methanol. Employees will use methanol in well-ventilated areas. Employees will practice proper personal hygiene – wash hands prior to eating/drinking, after decontamination procedures, and when leaving the site. During winter months, personnel will wear a pair of liner gloves underneath nitrile gloves.
	Liquinox©/ Alconox©	Sites.	Employees could be exposed to Liquinox©/ Alconox© via ingestion and	Employees will wear nitrile gloves and safety glasses during equipment decontamination.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
			skin/eye contact during equipment decontamination resulting in adverse health effects.	
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Improper lifting.	Sites.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry containers, decontamination solutions, and tools/equipment.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two people will lift awkward/heavy tools/equipment, if necessary.
GRAVITY	Falls from slips and trips.	Areas designated for decontamination procedures.	Slips and falls could occur while performing decontamination procedures due to slippery surfaces resulting in bruises, scrapes, or broken bones.	Workers will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.
	Dropping decontamination solution containers.	Work truck and decontamination site.	Decontamination solution containers could fall and strike worker while carrying them and pouring solution.	Workers will wear steel-toed boots and be cautious when carrying/moving containers.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites,	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when

HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

			and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Hypothermia/frost bite.	Sites where air temperature is 35.6°F (2°C) or less.	Workers whose clothing becomes wet during decontamination procedures may be exposed to hypothermia and/or frostbite.	Employees will change clothing, if it becomes wet.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
MECHANICAL	Pinch points.	Pumps.	Employees could be exposed to hand injuries such as pinched fingers when taking apart pumps for cleaning.	Employees will wear gloves when taking pumps apart for cleaning.
PRESSURE	Not applicable.			
THERMAL	Contact with hot surfaces.	Foil and decontamination equipment.	If foil and decontamination equipment (e.g., stainless steel pans) are placed directly in the sun, they could get hot. Contact with hot surfaces could result in personal injuries.	Personnel will prevent setting decontamination stations directly in the sun.
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves. Liner gloves, during winter months.
APPLICABLE SDS	Methanol and Liquinox©/ Alconox©. Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	Map with site location and sample locations.
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-SA-03B Preparation of Equipment Rinsate Blanks for Submersible Pumps
TOOLS	Pump, small swimming pool or plastic sheeting and pieces of PVC or boards, tap water, stainless steel pan or 5 gallon bucket/similar large container (to fit pump), Liquinox© or Alconox, DI water, plastic bags. Optional: bucket, hose, barrel, etc. for water containment, funnel, methanol.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**05/22/2015**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**05/22/2015**

APPROVALS/CONCURRENCE

By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for handling investigation-derived waste in accordance with the US Environmental Protection Agency (EPA) protocols and Department of Environmental Quality (DEQ) guidance. Investigation-derived waste may be generated during a Site Assessment (SA), Site Investigation (SI), or Remedial Investigation (RI).
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
1. Collect and dispose of decontaminati on fluids.	Collect and dispose of decontamination fluids by using one of the following methods: - Send fluids to a Treatment, Storage, and Disposal (TSD) facility. - Evaporate fluids. - Tread fluids using an activated carbon or air sparging unit. - Temporarily store fluids until determined if they are contaminated. Dispose of decontamination fluids, generated from cleaning equipment used in background sampling or for sampling in areas where past results indicate that contaminants are below standards, to the ground surface.
2. Discharge groundwater from developing and purging wells.	If past monitoring results and laboratory analysis indicate that all contaminants are below groundwater standards, discharge groundwater generated from developing and purging monitoring wells to the ground surface.
3. Collect/label/ store contaminated groundwater from developing and purging wells.	If past monitoring results indicate that one or more contaminants are above groundwater standards, collect the purged water and potentially contaminated water. There may be instances (e.g., inclement weather) where purge water and/or decontamination water will be temporarily stored in drums or tanks to be treated on site with granulated activated carbon or air sparging. If the water is determined by laboratory analysis to contain contaminants above groundwater standards and cannot be treated on site, store the water on site until shipping/disposal arrangements can be made. If the water is visibly contaminated, drum, label, and store the water on site until

	shipping/disposal arrangements are made. Label all containers stored on site with the following information: date, time, contents, any corresponding analytical data, collection location, contact person, and contact agency, etc.
4. Return soils back to borehole.	Unless it is visibly contaminated, place soil and/or cuttings from monitoring well installation back in the borehole.
5. Collect/label/ store contaminated soils from installing wells.	If the soil is visibly contaminated, drum, label, and store the soil/cuttings on site until shipping/disposal arrangements are made. Drum and label soils from borings/well installations located in previously sampled areas that are known to be contaminated. Leave these soils on site until shipping/disposal arrangements are made.
6. Pack and dispose of one-time use equipment and PPE.	Pack disposable equipment intended for one-time use and personal protective equipment (PPE) materials for appropriate disposal. Double bag the disposable equipment and PPE utilized for sampling and dispose of it as a solid waste in the local landfill. Package, drum, and label disposable equipment and PPE utilized for sampling visibly contaminated sites or sites known to be contaminated from previous monitoring. Leave equipment and PPE on site until shipping/disposal arrangements are made.
7. Dispose of samples not used for analysis.	Laboratories will dispose of the portions of the samples submitted, but not used for analysis. If samples are retained and not sent for analysis, they need to be returned to the site prior to remediation or disposed of according to federal and state regulations.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated soils and resulting water from decontamination procedures.	Sites.	Inadvertent exposure to contaminated soils and water resulting from decontamination procedures could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will follow decontamination procedures as described above. Employees will wear nitrile gloves and safety glasses when handling contaminated items.
	Nitric acid.	Sites.	Employees could be exposed to nitric acid via ingestion and skin/eye contact when decontaminating equipment. Exposure could cause irritation of skin/eye and adverse health effects.	Employees will prevent skin/eye contact with nitric acid and they will wear nitrile gloves and eye protection when handling nitric acid. Employees will practice proper personal hygiene – wash hands prior to eating/drinking, after decontaminating equipment, and when leaving the site. Refer to the Chemical Flushing Guidelines available inside vehicle's first aid kit for first-aid procedures in case of contact with nitric acid.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Improper shoveling techniques.	Sites.	Personnel could be injured if using improper shoveling techniques to store contaminated soils/cuttings in drums, causing back injuries and muscle/back strains.	Personnel will use proper shoveling techniques: keep feet wide apart, place front foot close to shovel, put weight on front foot, use leg to push shovel, shift weight to rear foot, keep load close to body, and turn feet in direction of throw.

HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

	Improper lifting.	Sites.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry 5-gallon containers of tap water.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Hypothermia/frost bite.	Sites where air temperature is 35.6°F (2°C) or less.	Workers whose clothing becomes wet during decontamination procedures may be exposed to hypothermia and/or frostbite.	Employees will change clothing, if it becomes wet.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be	Employees will follow the 30/30 rule during lightning storms.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
			caused by lightning strike.	
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
APPLICABLE SDS	Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants. Nitric acid.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-DE-02 Equipment Decontamination.
TOOLS	Five 5-gallon buckets, tap water, stiff brushes, soap, de-ionized or distilled water, nitric acid (if required), plastic sheeting or foil, tarps, decontamination tubs and buckets, sprayers, storage containers, labels, and shovels.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**12/03/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**12/03/2014**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for mobilizing and loading/unloading the Geoprobe® Model 66DTX.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Mobilizing and Demobilizing the Geoprobe® to and from the Job Site	*Trailer Checklist* The trailer checklist ensures that the trailer is properly connected to the Geoprobe® work truck. 1. Make sure the hitch is connected to the truck with the hitch pin and clip (Figure 1). This will ensure that the hitch will not detach from the truck during transport. 2. Turn on the work truck (the work truck is a diesel so allow the glow plugs to warm up). To warm the glow plugs, turn the power on to the truck and there will be a light that looks like a pig tail (Figure 2). When this light goes off the glow plugs are warmed and the truck can be started. 3. Using a spotter, back the truck up so the ball on the truck hitch is right below the female ball connection on the trailer hitch. If a spotter is not available, there is a center line mark on the tailgate of the work truck (Figure 3). If you are alone take your time and get out of the truck and check distances multiple times so there is not damage caused to either the truck or the trailer. Although it is possible to attach the work truck to the trailer with one person, it is a better procedure to use a spotter. 4. When the ball of the truck hitch is located under the female ball connection on the trailer, pull the trailer lock latch up so the ball will freely insert into the trailers hitch connection (Figure 4). 5. Turn the front trailer jack's crank counter -clockwise to lower trailer onto the truck's hitch (Figure 5). 6. Lower the trailer lock latch and lock it in place with its pin and carrier (Figure 6).

7. When the trailer is locked to the truck hitch, pull the clip and safety pin from the front jack's foot plate (Figure 7) and move the foot plate up into the jack and replace the safety pin and clip (Figure 8).

8. Attach the trailer sway bars (Figure 9) to the truck hitch. The front end of the trailer sway bars has two rounded sections on them. This rounded section will be placed inside the trucks hitch with the sticker on the sway bar facing upward (Figure 10). The back end of sway bar has a length of chain on it. This will attach to the trailer hitch. Pull the safety pin from the trailer hitch connection hinge (Figure 11) and lower the trailer hitch connection hinge. Count 5 full links of chain from the sway bar and place the fifth link onto the hook of trailer hitch connection hinge. Take a cheater bar (e.g., small section of pipe) and lift the hinge up into place (Figure 12), while making sure the sway bar chain is still attached to the hook. When the hinge is back in place, replace the safety pin to ensure the hinge will not unlock and drop the sway bar.

9. Attach the trailer safety chains to the trucks hitch system (Figure 13). This is a safety precaution. In case the trailers hitch becomes unattached from the truck, the trailer will still be attached to the trucks hitch system.

10. Attach the trailers brake and power cord to the power output connection on the truck (Figure 14).

NOTE: *make sure that the power cord is not touching or close to touching the ground. If the power cord comes in contact with the ground, it can ruin the cord and cause the trailers lighting and braking system to quit working.*

11. Make sure the support jacks are in the upright position and locked with their automatic locking pin (Figure 15).

12. Ensure the Geoprobe® is centered in the trailer. Refer to SOP-GEOPROBE-04 Driving the Geoprobe® Model 66 DTX for driving procedures.

13. Make sure the back white cross bar (Figure 16) is in line with the pre-marked line inside the trailer (Figure 17). This will center the weight of the Geoprobe® inside the trailer.

14. Attach the front ratchet strap to the front strap connection (Figure 18) on the Geoprobe® and the front strap ring (Figure 19) located on the floor towards the front of the trailer. Tighten the ratchet strap so there is very little slack in the strap.

15. Attach the second ratchet strap to the left back strap ring (Figure 20) located at the rear of the trailer. Wrap the strap around the black chassis cross bar (Figure 21) a complete revolution. Attach the other end of the ratchet strap to the right back strap ring (Figure 22) located at the rear of the trailer. Tighten the strap so there is very little slack in the strap.

	16. Make sure the trailer doors are all locked during transport. 17. Ensure all jacks are up off the ground and secure. Verify that the safety chains, pins, and power cord are all attached and secure. 18. Take the chalks out from under the tires. The Geoprobe® is now ready for mobilization to and from job sites.
Unloading the Geoprobe®	Before unloading and loading the Geoprobe® set the truck's parking brake and place the tire chalks under the front and rear of one side of the tires on the trailer (Figure 23). Make sure when loading and unloading the Geoprobe® that the trailer is on level ground if not slightly going downhill. This will make it easier to load and unload the rig. 1. After the truck brake and chalks are set, pull the safety pin on the back jacks and place them in the lifting position. Turn the jack handles counter-clockwise until the base of the jack just comes into contact with the existing ground (Figure 24). 2. Pull the ramps from the back of the trailer and place their stub pins into the holes located at the very rear of the trailer (Figure 25). These ramps are made of steel and can be heavy. Use a two person lift or proper techniques when lifting the ramps. 3. Take the front and back ratchet straps off of the Geoprobe®. 4. Start the rig and allow the Geoprobe® fluids time to warm up. Refer to SOP-GEOPROBE-03 Starting and Stopping the Kubota Engine for procedures on how to start the motor. 5. Make sure the rigs parking brake lock is pressed down or in the off position. 6. Use the rig helper as a spotter when the rig is being unloaded. Make sure the spotter is behind the rig but off to the side in case the rig decides to free wheel backwards. This should not happen, but as a precaution the operator should be ready to move the track control levers forward to stop the reverse motion. 7. The operator should make sure that the throttle on the rig is one to two steps down from full throttle and that the operating pressure switch is turned on. 8. Start backing out the rig slowly. Pay attention to the left side track and make sure that the track is centered in the ramp. When backing up the rig, the front of the machine will lift off of the trailer and the back of the machine will lower to the ramps; this will happen when

	the center of gravity is at the end of the trailer. The operator should always stay on the seat. When unloading or loading for the first time, an experienced rig operator should be on location to help coach the loading and unloading. 9. Make sure the rig comes completely off of the ramps and back out another 4 to 5 feet to give enough room for the pre-job inspection (SOP-GEOPROBE-02 Pre-Job and Post-Job Inspection).
Loading the Geoprobe®	Make sure when loading and unloading the Geoprobe® that the trailer is on level ground if not slightly going downhill. This will make it easier to load and unload the rig. 1. Make sure the rig is completely off of the ramps and back out another 4 to 5 feet to give enough room for the post-job inspection (SOP-GEOPROBE-02 Pre-Job and Post-Job Inspection). 2. Connect the truck to the trailer. Ensure the truck brake is set and the chalks are set on the trailer. 3. Pull the ramps from the back of the trailer and place their stub pins into the holes located at the very rear of the trailer (Figure 25). These ramps are made of steel and can be heavy; use a two person lift or proper techniques when lifting the ramps. 4. Start the rig and allow the Geoprobe® fluids time to warm up. Refer to SOP-GEOPROBE-03 Starting and Stopping the Kubota Engine for procedures on how to start the motor. 5. Make sure the rigs parking brake lock is pressed down or in the off position. 6. The operator should make sure that the throttle on the rig is one to two steps down from full throttle and that the operating pressure switch is turned on. 7. Start moving forward up the ramps. The operator must pay attention to the left track and make sure it is centered in the left ramp. When the center of gravity is reached at the end of the trailer, the front of the rig will fall into the trailer and the back of the rig will leave the ramps. 8. Make sure the rig is centered in the trailer and the back white cross bar is lined up with the pre-marked line in the trailer to center the weight. Loading the Geoprobe® is complete.

HSSE CONSIDERATIONS

This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	*HAZARDS*	*WHERE*	*HOW, WHEN, RESULT*	*CONTROLS*
CHEMICAL	Hydraulic fluid and diesel.	Geoprobe®.	Employees could be exposed to hydraulic fluid and/or diesel via inhalation, ingestion, and skin/eye contact, when operating the Geoprobe®, or if equipment malfunctions resulting in adverse health effects.	Employees will wear work gloves and eye protection, if contact with hydraulic fluid/diesel is possible. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe® trailer. Cleanup materials will be disposed of according to the appropriate regulations. All components of the rig will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
PRESSURE	Pressurized hydraulic lines.	Geoprobe®.	Faulty pressurized hydraulic lines could burst resulting in personal injury/exposure and hydraulic fluid release.	All components of the rig will be inspected prior to and at the completion of the task.
	Excessive noise levels.	Geoprobe®.	Employees could be exposed to excessive noise levels when driving the Geoprobe® resulting in irritability, decreased concentration, and noise-induced hearing loss.	Personnel driving the Geoprobe® will wear single hearing protection (i.e., earmuffs). Non-essential personnel will maintain a 20-foot buffer zone around the rig.

ELECTRICAL	Defective electrical lines.	Geoprobe®.	Contact with defective electrical lines could result in personal injury.	Inspect electrical lines of the Geoprobe® prior to and at the completion of the task.
	Lightning.	All sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
MOTION	Backing up the work truck.	Sites.	Incidents could occur when backing up the work truck to connect the trailer to the truck resulting in personal injury and/or property damage.	Use a spotter when backing up the work truck. If a spotter is not available, walk around the truck to check distances and look for obstacles that may be in your blind spots. The spotter will wear high visibility clothing.
	Towing the Geoprobe's trailer.	Road.	Incidents could occur when towing the Geoprobe's trailer to the job site resulting in personal injury and/or property damage.	Driver will follow defensive driving techniques and will be trained on how to properly tow a trailer.
	Improper lifting.	Sites.	Back injuries and muscle/back strains could result when using improper techniques to lift the trailer's ramps.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder height. When necessary, two persons will lift the ramps.
	Pinch points.	When mobilizing and demobilizing the Geoprobe®.	Employees could be exposed to hand injuries, such as lacerations, punctures, cuts,	Personnel will wear work gloves.

			and pinched fingers, when connecting the trailer to the work truck and loading/ unloading the Geoprobe®.	
	Struck by the work truck, trailer, and/or Geoprobe®.	Loading/ unloading the Geoprobe®.	Personnel could be injured if struck by the work truck, trailer, or Geoprobe®.	Set the truck's parking brake and place the tire chalks under the tires of the trailer before unloading and loading the Geoprobe®. When unloading the rig, the spotter will always stand to the side of the ramps and never behind the rig. Spotters will wear high visibility clothing. Non-essential personnel will maintain a 20-foot buffer zone around the rig. Use traffic cones to delineate the space needed to load/unload the rig.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Employees will plan their path and walk cautiously. Keep work area free of tools/rods. If conditions are wet/muddy, muck boots may be worn. Site can be cleared of snow, if applicable.
	Falls.	Geoprobe®.	Operator could fall off of the rig during loading/ unloading resulting in bruises, scrapes, or broken bones.	The operator should always stay on the seat. When unloading, the operator will grab onto the back of the trailer before the rig's center of gravity is reached.

	Geoprobe® falling off of ramps.	Geoprobe®.	The rig could fall off of the ramps when loading/ unloading resulting in personal and property damage.	Use a spotter when loading/unloading the Geoprobe®. Workers will use special caution when loading the rig onto a trailer with wet ramps. It is significantly easier for the tracks to slip under such conditions.
THERMAL	Cold/heat stress.	Outdoors.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear sunscreen, long-sleeve work shirts and long pants. Employees will also use safety glasses with tinted lenses.
BIOLOGICAL	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. When loading/unloading for the first time, an experienced operator should be on site to help coach the loading/unloading process. All employees operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency Kill switch button.

	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies should notify their supervisor.

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Level D PPE and single hearing protection (e.g., ear muffs).
APPLICABLE MSDS	MSDSs will be maintained based on site characterization and contaminants. Hydraulic fluid and diesel.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-GEOPROBE-02 Pre-Job and Post-Job Inspection SOP-GEOPROBE-03 Starting and Stopping the Kubota Engine SOP-GEOPROBE-04 Driving the Geoprobe® Model 66 DTX
TOOLS	
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
SAFETY AND HEALTH MANAGER	**DATE**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for conducting a pre-job and post-job Geoprobe® inspection.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Placement of the Geoprobe®	1. Place the Geoprobe® on flat ground. 2. Unfold the derrick by pushing the fold lever (Figure 1) downward. Unfold the derrick until the foot of the Geoprobe® is parallel to the ground (Figure 2). 3. Lower the foot of the rig until it touches the ground by pushing the foot lever downward (Figure 3). 4. Turn off the Geoprobe®.
Engine Hours	1. Locate the run time odometer on the control panel and write down the machines current hours (Figure 4).
Engine Compartment	1. Open the engine compartment. ***CAUTION:*** *if you are performing the Post-Job checklist allow at least 10 minutes for the engine to cool before checking any fluids.* 2. Check the engine oil level using the oil dip stick. 3. Check the engine coolant fluid level inside the radiator by taking the radiator cap off (Figure 5). ***CAUTION:*** *make sure to wear leather gloves when taking the radiator cap off of the radiator.* 4. Check the coolant level in the coolant reservoir (Figure 6). 5. Check the hydraulic fluid level by reading the sight glass located behind the driver seat (Figure 7).

	6. Make sure the hydraulic fluid cap, fuel cap, and radiator cap are all in place. 7. Check the radiator for leaks, cracks, and cleanliness. 8. Locate the battery, fuse, and the relay box by opening the door on the pipe rack side of the Geoprobe®. Check the battery, fuse, and relay box. Make sure they are clean and free of corrosion. 9. Make sure the belts are in good condition and set at proper tension. 10. Close the engine compartment.
Machine Chassis	1. Make sure the tracks are in good condition and at the proper tension. The tracks should have 3-inches of slack in them (Figure 8). 2. Grease chassis as required. 3. Check the hydraulic cylinders for leaks. Use the grease gun and place the nozzle on the grease fittings and pump the grease gun (Figure 9). 4. Check the hydraulic hoses and fittings for leaks. ***NOTE:*** *if hydraulic fittings are loose, tighten them. If hoses are leaking or fittings cannot be tighten, immediately stop work and replace the given fittings and/or hoses.* 5. Check the frame for cracks or damage. 6. Ensure the basket is attached to rear hitch of the Geoprobe® with the hitch pin and safety pin. 7. Ensure the fire extinguisher is inspected and located in the basket at all times during geoprobing. 8. Ensure the emergency stops (Figure 10) are working correctly by starting the Geoprobe® and pushing each emergency stop button. If the machine stops when the emergency stops are hit, the emergency stops are working. If the emergency stops are not working, they must be fixed prior to proceeding with the work. 9. Check the hose carriers/housings for breaks in brackets.
Control Panel and Accessories	1. Ensure all gauges are operating properly. 2. Ensure all control levers are in the neutral position and are secure.

	3. Ensure all control switches are operating properly. 4. Check the winch line and winch safety hook for any damage or fraying. 5. If the drop hammer is being used, make sure it is secured. Check the hoses coming from the drop hammer and also make sure the auxiliary hydraulic line and fittings are free of leaks. Refer to SOP-GEOPROBE-09 DH66 Automatic Drop Hammer to see drop hammer securing procedures.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Hydraulic fluid, diesel, engine oil, coolant fluids, battery fluids, and lubricating grease.	Hydraulic lines, engine, radiator, and chassis.	Employees could be exposed to hydraulic fluid, diesel, engine oil, coolant fluids, battery fluids, and lubricating grease via inhalation, ingestion, and skin/eye contact, when inspecting the Geoprobe®, or if equipment malfunctions resulting in adverse health effects.	Employees will wear work gloves and eye protection, if contact with fluids is possible. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe® trailer. Cleanup materials will be disposed of according to the appropriate regulations. All components of the rig will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
PRESSURE	Pressurized hydraulic lines.	Geoprobe®.	Faulty pressurized hydraulic lines could burst resulting in personal injury/exposure and hydraulic fluid release.	All components of the rig will be inspected prior to and at the completion of the task.
	Excessive noise levels.	Geoprobe®.	Employees could be exposed to excessive noise levels when starting and running the Geoprobe® resulting in irritability, decreased concentration, and noise-induced hearing loss.	The operator will wear single hearing protection (i.e., earmuffs). Non-essential personnel will maintain a 20-foot buffer zone around the rig.

ELECTRICAL	Defective electrical lines.	Geoprobe®.	Contact with defective electrical lines could result in personal injury.	Inspect electrical lines of the Geoprobe® prior to and at the completion of the task.
	Lightning.	All sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
	Contact with overhead utilities.	Unfolding/ folding the derrick.	Injury, death, or property damage could occur from contact with overhead utilities when unfolding/folding the derrick.	If overhead hazards are present, established overhead utility procedures will be followed. Working location will be moved to avoid unfolding/folding the derrick around overhead utilities. Employees will maintain the required minimal radial clearance distances based on voltage when working around overhead lines.
MOTION	Contact with moving parts of the Geoprobe®.	Unfolding/ folding the derrick and lowering the foot of the Geoprobe®.	Fingers/hands could become pinched or caught in moving parts of the Geoprobe® resulting in cuts, scrapes, and/or broken bones.	All personnel will be clear of all moving parts before unfolding/folding the derrick and lowering the foot of the Geoprobe®.
	Pinch points.	Geoprobe®.	Employees could be exposed to hand injuries such as lacerations, punctures, cuts, and pinched fingers when opening/closing the rig's compartment doors to perform inspections.	Employees will wear work gloves when conducting pre- and post-job inspections.

GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Employees will plan their path and walk cautiously. Keep work area free of tools/rods. If conditions are wet/muddy, muck boots may be worn. Site can be cleared of snow, if applicable.
THERMAL	Cold/heat stress.	Outdoors.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Hot Geoprobe® surfaces, components, and fluids.	Post-job inspections.	Direct contact with hot Geoprobe® surfaces, components, and fluids (e.g., engine compartment, radiator cap, engine oil, and coolant) could result in skin burns and skin/eye damage.	Allow time for the engine and fluids to cool before performing the post-job inspection (at least 10 minutes). Employees will wear work gloves and safety glasses.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear sunscreen, long-sleeve work shirts and long pants. Employees will also use safety glasses with tinted lenses.

BIOLOGICAL	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. All employees operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency Kill switch button.
	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies should notify their supervisor.

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Level D PPE and single hearing protection (e.g., ear muffs).
APPLICABLE MSDS	MSDSs will be maintained based on site characterization and contaminants. Hydraulic fluid, diesel, engine oil, coolant fluids, battery fluids, and lubricating grease.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-GEOPROBE-09 DH66 Automatic Drop Hammer
TOOLS	
FORMS/CHECKLIST	Inspection checklist.

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
SAFETY AND HEALTH MANAGER	**DATE**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for starting and stopping the Kubota Diesel Engine on the Geoprobe®.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Preparing the Engine for Start Up	1. Make sure that all both kill switches are depressed (Figure 1). 2. Verify that the Geoprobe® is in an open area for ventilation. If the Geoprobe® is in the trailer, completely open the front and back doors to help with ventilation.
Starting the Kubota Engine	1. Make sure that the Geoprobe® throttle switch is one step up from the lowest idle (i.e., fast idle). 2. Warm the glow plugs before starting. To warm the glow plugs, turn the key counter-clockwise (Figure 2). The red light, located near the ignition, will light up as the glow plugs warm. As soon as the glow plugs are warmed, the red light will go out. ***NOTE:*** *in cold weather conditions, it is good practice to warm the glow plugs twice. Also, if the machine has been warmed up and been running, then there is no need to warm the glow plugs again before start up.* 3. Ensure that the Operating Pressure (Figure 3) and the Auxiliary Hydraulics (Figure 4) switches are both located in the "OFF" position. The "OFF" position is when the switches are in the bottom position. 4. To start the starter motor, turn the ignition key clockwise. Release the ignition key when the engine starts and runs on its own power. ***IMPORTANT:*** *do not run the starter motor for longer than 10 seconds. If the engine does not start running, then allow 30 seconds to go by and repeat the starting procedure.* 5. Make sure the oil pressure gauge (Figure 5) is reading around or

	above 5 psi and the battery gauge (Figure 6) reads 12-16 Volts (Refer to the Kubota Engine Manual for troubleshooting procedures). 6. Allow the engine to run at least 15 minutes to bring the coolant and hydraulic fluid up to running temperature before geoprobing is commenced.
Running the Kubota Engine	1. When the engine is running during sampling procedures, turn off the operating pressure switch and lower the throttle switch to a slow or fast idle (i.e., lowest or second lowest gear position). This will help to conserve fuel and will prolong the engine life.
Stopping the Kubota Engine	1. Return the idle switch to fast idle (i.e., one step above the lowest position). 2. Run the engine at fast idle for a few minutes to allow for the engine and fluids to cool. 3. Turn the ignition key to the “OFF” position (Figure 7). ***IMPORTANT:*** *familiarize yourself with the engine kills switches so in case of an emergency these switches can be easily used.*

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Hydraulic fluid and diesel.	Geoprobe®.	Employees could be exposed to hydraulic fluid and/or diesel via inhalation, ingestion, and skin/eye contact, when operating the Geoprobe®, or if equipment malfunctions resulting in adverse health effects.	Employees will wear work gloves and eye protection, if contact with hydraulic fluid/diesel is possible. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe® trailer. Cleanup materials will be disposed of according to the appropriate regulations. All components of the rig will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
	Carbon Monoxide (CO).	Trailer.	Potential exposure to CO when starting the engine inside the trailer could result in irritated eyes, headache, nausea, weakness, and dizziness.	If the engine is started inside the trailer, open both doors of the trailer to help with ventilation. Step outside the trailer after starting the engine. Do not work around the exhaust area located in the back of the Geoprobe®.
PRESSURE	Pressurized hydraulic lines.	Geoprobe®.	Faulty pressurized hydraulic lines could burst resulting in personal injury/exposure and hydraulic fluid release.	All components of the rig will be inspected prior to and at the completion of the task.
	Excessive noise levels.	Geoprobe®.	Employees could be exposed to excessive noise levels when starting and	The operator will wear single hearing protection (i.e., earmuffs). Non-essential personnel will maintain a 20-foot buffer zone around the rig.

			running the Geoprobe® resulting in irritability, decreased concentration, and noise-induced hearing loss.	
ELECTRICAL	Defective electrical lines.	Geoprobe®.	Contact with defective electrical lines could result in personal injury.	Inspect electrical lines of the Geoprobe® prior to and at the completion of the task.
	Lightning.	All sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
MOTION	Contact with rotating and moving parts of the Geoprobe®.	Starting the engine.	Fingers/hands could become pinched or caught in moving/rotating parts of the Geoprobe® resulting in cuts, scrapes, and/or broken bones.	All personnel will be clear of all moving/rotating parts before starting the engine.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Employees will plan their path and walk cautiously. Keep work area free of tools/rods. If conditions are wet/muddy, muck boots may be worn. Site can be cleared of snow, if applicable.

THERMAL	Cold/heat stress.	Outdoors.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear sunscreen, long-sleeve work shirts and long pants. Employees will also use safety glasses with tinted lenses.
BIOLOGICAL	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. All employees operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency Kill switch button.
	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies should notify their supervisor.

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Level D PPE and single hearing protection (e.g., ear muffs).
APPLICABLE MSDS	MSDSs will be maintained based on site characterization and contaminants. Hydraulic fluid, diesel, and carbon monoxide.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	Kubota Engine Manual
TOOLS	
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE

By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.

SOP TECHNICAL AUTHOR	DATE
SAFETY AND HEALTH MANAGER	**DATE**

APPROVALS/CONCURRENCE

By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for driving and positioning the Geoprobe® Model 66DTX for probing.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Driving and Braking Controls on the Geoprobe® Model 66DTX	***Brakes*** The Geoprobe® Model 66DTX is equipped with automatic track brakes. When the engine is not running, the track brakes are automatically engaged. When the engine is running or when the rig is on steep slopes, the Track Brake Lock can be engaged. The Track Brake Lock is located in front of the driver seat on the rig. To set the brake, push the top of the switch (Figure 1). ***Hydraulic Steering Controls*** The Model 66DTX has two steering control levers (Figure 2) that control two independently controlled tracks. The left lever controls the left track and the right lever controls the right track. To move forward, move both control levers forward. To move in reverse, move both control levers towards the back of the machine. There are three types of turns the Model 66DTX can accomplish. These turns are listed and described below. 1. **Gradual Turn** This turn is used when the rig is in motion. By moving the control levers in the same direction but to different degrees, will produce a gradual turn. This turn is possible in both forward and reverse directions. 2. **Pivot Turn** This turn is used when the rig is stationary. By moving one control lever and leaving the other control lever in neutral position, will produce a pivot turn. The turn will center around the track that is stationary. This turn is used frequently when positioning the rig over probe-hole locations. This turn is possible in both forward and reverse directions. 3. **Counter-Rotation Turn** This turn is used when the rig is stationary. By moving both controls but in

	opposite directions, will produce a counter-rotation turn. This turn will center around the center of the rig. The counter-rotation turn is used widely in congested areas with limited room to turn.
Driving the Geoprobe® Model 66DTX	***CAUTION:*** *when driving the rig, always remain in the driver seat of the rig. Use a spotter to obtain the best and safest route to the probe-hole locations and when avoiding obstacles.* 1. Start the Geoprobe® Model 66DTX as stated in SOP-GEOPROBE-03 Starting and Stopping the Kubota Engine. 2. Do a complete walk around the rig and verify that the back hydraulic outriggers (Figure 3) are in the upright position and that all other rig extremities are free of debris/obstacles. 3. Ensure the rig is in transport position. Transport position is when the rig is completely folded up. • The probe cylinder must be lowered all the way to the foot (Figure 4). To lower the foot, place the probe lever (Figure 5) in the downward position until motion has halted. • The foot must be completely raised up to the folding bracket (Figure 6). To raise the foot, place the foot lever (Figure 5) in the upward position until motion has halted. • The mast must be completely lowered to the folding bracket (Figure 7). To lower the mast, place the mast lever (Figure 5) in the downward position until motion has halted. • The winch line should be spooled up and the winch should be pulled to one side or the other (Figure 8) so it does not fall back on the mast when the rig is folded. To ensure the winch is located to either side of the mast, let out enough line to grab on to the winch line and swing the winch to either side. To lower the winch line, place the winch lever (Figure 5) in the downward position until the safety hook can be reached. When the winch is located to either side of the rig, place the winch lever in the upward position to start pulling in the winch line. When the safety cylinder (Figure 9) comes within a couple inches of the winch spool, place the winch lever back to the neutral position. ***NOTE:*** *do not pull all the winch line in. Allow a couple inches of slack in the winch line so the line or winch does not get damaged.* • Fold up the rig completely. To fold up the rig, place the fold lever in the upward position until motion has halted. ***CAUTION:*** *make sure to pay close attention to the winch hoses so they do*

	not get pinched by any portion of the rig when folding it up. 4. Move the rig to the specified location using the track control levers and turns as necessary. ***IMPORTANT:*** *DO NOT SIDE HILL WITH THE RIG. When traversing through mountainous and hilly areas, drive straight up or down the terrain.*
Positioning the Geoprobe® Model 66DTX	***CAUTION:*** *the rig operator should always remain in the driver's seat when the rig is being positioned. Use a spotter to position the rig.* 1. After the rig has been driven close to the probe hole (no farther than five feet away), unfold the derrick of the machine. To unfold the derrick, place the fold lever in the downward position until the foot of the machine is parallel to the existing ground. 2. Raise the mast completely up. To raise the mast, place the mast lever in the upward position until motion is halted. 3. Lower the foot until there is roughly six to twelve inches between the bottom of the foot and the existing ground. To lower the foot, place the foot lever in the downward position until the desired position is reached. 4. Raise the probe cylinder three to four feet off of the foot. To raise the probe cylinder, place the probe lever in the upward position until the desired position is reached. 5. Ensure the machine is extended in about half-way (six to seven and a half inches). To extend the machine in and out, place the extend lever (Figure 5) in the upward position to move the machine in, and place the extend lever in the downward position to extend out. 6. The rig operator should now move the Geoprobe® into position, while using a spotter to give him/her directions. The operator should place the rig as close to the staked borehole as possible.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Hydraulic fluid and diesel.	Geoprobe®.	Employees could be exposed to hydraulic fluid and/or diesel via inhalation, ingestion, and skin/eye contact, when operating the Geoprobe®, or if equipment malfunctions resulting in adverse health effects.	Employees will wear work gloves and eye protection, if contact with hydraulic fluid/diesel is possible. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe® trailer. Cleanup materials will be disposed of according to the appropriate regulations. All components of the rig will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
PRESSURE	Pressurized hydraulic lines.	Geoprobe®.	Faulty pressurized hydraulic lines could burst resulting in personal injury/exposure and hydraulic fluid release.	All components of the rig will be inspected prior to and at the completion of the task.
	Excessive noise levels.	Geoprobe®.	Employees could be exposed to excessive noise levels when driving and positioning the Geoprobe® resulting in irritability, decreased concentration, and noise-induced hearing loss.	Personnel driving and positioning the Geoprobe® will wear single hearing protection (i.e., earmuffs). Non-essential personnel will maintain a 20-foot buffer zone around the rig.

ELECTRICAL	Defective electrical lines.	Geoprobe®.	Contact with defective electrical lines could result in personal injury.	Inspect electrical lines of the Geoprobe® prior to and at the completion of the task.
	Lightning.	All sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
	Contact with overhead utilities.	Sites.	Injury, death, or property damage could occur from contact with overhead utilities if the Geoprobe® is driven with the mast up and when raising the mast up to position the rig close to the probe hole.	If overhead hazards are present, established overhead utility procedures will be followed. Employees will not drive the Geoprobe® with the mast extended. The rig must be completely folded up before driving it. Probe locations will be moved to avoid working around overhead utilities. Employees will maintain the required minimal radial clearance distances based on voltage when working around overhead lines.
MOTION	Driving and positioning the Geoprobe®.	Sites.	Personal injury and equipment damage could occur when driving the rig to the probing location and when positioning the rig close to the probe hole.	Employees will drive and position the rig only while sitting on the driver's seat. Do not move the rig by manipulating the hydraulic steering controls while standing on the ground. Use a spotter to obtain the safest route to the probe-hole locations, avoid obstacles while driving, and position the rig. The spotter will wear high visibility clothing. Non-essential personnel will maintain a 20-foot buffer zone around the rig. Do not attempt to traverse slopes greater than 30 degrees.

				The unit may freewheel and pick up speed when traversing steep slopes. Activate the track brake lock to slow the vehicle as needed.
	Geoprobe® tipping over.	Steep terrain.	Personal injury and equipment damage could occur if the Geoprobe® tips over while driving over steep terrain and positioning Geoprobe® over steep terrain.	Do not side hill with the rig. When traversing through mountainous and hilly areas, drive straight up or down the terrain. A spotter will guide the operator while driving over steep terrain. The spotter will wear high visibility clothing. Non-essential personnel will maintain a 20-foot buffer zone around the rig. Do not raise the rig's tracks off of ground when positioning the Geoprobe® on steep slopes or in soft soil. Operate engine at a moderate speed when positioning probe unit.
	Struck by the Geoprobe®.	Driving and positioning the Geoprobe®.	Personnel could be injured if struck by the Geoprobe® while driving and positioning the unit.	The spotter guiding the operator will wear high visibility clothing. Non-essential personnel will maintain a 20-foot buffer zone around the rig.
	Contact with rotating and moving parts of the Geoprobe®.	Prepping the Geoprobe® for mobilization, driving, and positioning the Geoprobe®.	Fingers/hands could become pinched or caught in moving/rotating parts of the Geoprobe® resulting in cuts, scrapes, and/or broken bones.	Employees will not touch moving/rotating parts of the rig. Personnel will tie back long hair and will not wear loose clothing when operating the machine. Work gloves are required when operating the rig.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and	Walking on slick/muddy/wet and uneven	Workers will wear work boots with good traction and ankle

		steep slopes.	terrain could cause slips and trips resulting in falls and injuries.	support. Employees will plan their path and walk cautiously. Keep work area free of tools/rods. If conditions are wet/muddy, muck boots may be worn. Site can be cleared of snow, if applicable.
THERMAL	Cold/heat stress.	Outdoors.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear sunscreen, long-sleeve work shirts and long pants. Employees will also use safety glasses with tinted lenses.
BIOLOGICAL	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. All employees operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency Kill switch button.
	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes,	Training on the signs and symptoms of exposure to plants, insects, and animals. Avoid contact with plants,

			blisters, redness, and swelling.	insects, and animals. First-aid kits will be available on site. Employees with allergies should notify their supervisor.

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Level D PPE and single hearing protection (e.g., ear muffs).
APPLICABLE MSDS	MSDSs will be maintained based on site characterization and contaminants. Hydraulic fluid and diesel.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-GEOPROBE-03 Starting and Stopping the Kubota Engine.
TOOLS	
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
SAFETY AND HEALTH MANAGER	**DATE**

APPROVALS/CONCURRENCE	
By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for constructing tool strings and sampling procedures using the Geoprobe® Model DT-22 Dual Sampling System.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
DT-22 Expendable Cutting Shoe Tool String Set Up	The procedure for operating the Geoprobe® can be reviewed in SOP-GEOPROBE-07 Operating the Geoprobe® During Probing Operations. Figure 1 depicts the DT-22 tool string diagram. The expendable cutting shoes are used to collect samples. When sampling is complete, tooling or equipment (e.g., monitoring wells) can be placed or constructed inside the hole. The following instructions describe how to set up the expendable cutting shoe tool string. 1. The expendable cutting shoe (Figure 2) has two spaces on the neck portion of the tool. Lubricate an O-ring with Liquinox. Place the lubricated O-ring on the top most space. 2. Take the expendable cutting shoe, with the O-ring inserted, and place the cutting shoe into the expendable cutting shoe holder (Figure 3). 3. Thread the expendable cutting shoe holder onto the female end of the 2.25-inch probe rod. 4. Attach the 1.125-inch core liner to the liner driver head. • Take a small piece of light weight inner rod and attach it to the pipe tri-stand. • Thread the liner driver head into the piece of lightweight inner rod. • Push the core liner onto the liner driver head and line up the hole on the top part of the core liner with the set screw hole on the liner drive head. • Place a set screw in the hole and tighten it down with a 3/32 Allen wrench.

	5. Unscrew the liner drive head with the sample core liner attached and place it inside the probe rod. **NOTE:** *if the bore hole is deeper than four feet, then light weight center rods need to be attached to the liner drive head so that four feet of lightweight center rod comes out of the probe rod.* 6. Place an extra four feet of light weight center rod onto the center rods or sample drive head. 7. Place another probe rod over the light weight center rod and thread it onto the lower probe rod until the seam is tight. 8. Place the rubber bumper onto the top light weight center rod or the liner drive head. 9. Place the drive cap over the threads of the probe rods. The tool string is now complete and ready for probing.
DT-22 Attached Cutting Shoe Tool String Set Up	The attached cutting shoes are used to collect soil samples. 1. Thread the attached cutting shoe onto the female end of the DT-22 probe rod. 2. Attach the 1.125-inch core liner to the liner driver head. • Take a small piece of light weight inner rod and attach it to the pipe tri-stand. • Thread the liner driver head into the piece of lightweight inner rod. • Push the core liner onto the liner driver head and line up the hole on the top part of the core liner with the set screw hole on the liner drive head. • Place a set screw in the hole and tighten it down with a 3/32 Allen wrench. 3. Unscrew the liner drive head with the sample core liner attached and place it inside the probe rod. **NOTE:** *if the bore hole is deeper than four feet, then light weight center rods need to be attached to the liner drive head so that four feet of lightweight center rod comes out of the probe rod.* 4. Place an extra four feet of light weight center rod onto the center rods or sample drive head. 5. Place another probe rod over the light weight center rod and thread

	it onto the lower probe rod until the seam is tight. 6. Place the rubber bumper onto the top light weight center rod or the liner drive head. 7. Place the drive cap over the threads of the probe rods. The tool string is now complete and ready for probing.
DT-22 Expendable Point Tool String Set Up	The expendable points are used when collecting samples is not needed, but tooling or equipment (e.g., monitoring wells) are to be placed or constructed inside the hole. 1. The expendable point has two spaces on the neck portion of the tool. Lubricate an O-ring with Liquinox. Place the lubricated O-ring on the top most space. 2. Take the expendable point, with the O-ring inserted, and place the cutting shoe into the expendable point holder (Figure 3). 3. Thread the expendable point holder onto the female end of the 2.25-inch probe rod. 4. Place the drive cap over the threads of the probe rods. The tool string is now complete and ready for probing.
DT-22 Attached Point Tool String Set Up	The attached points are used when collecting samples is not needed and tooling or equipment (e.g., monitoring wells) will not be placed or constructed inside the hole. 1. Thread the attached point holder onto the female end of the 2.25-inch probe rod. 2. Place the drive cap over the threads of the probe rods. The tool string is now complete and ready for probing.
Cutting the DT-22 Sample Liners	1. Unfold the sample table. 2. Place the aluminum sample core liner holder on the table and tighten the holder to the table with the clamps. 3. Place the core liner that needs to be sampled on the aluminum holder. Place the liner so that the core catcher end of the liner goes over the sample holders spear. 4. Place the DT-22 core liner cutter at the top of the core liner and pull all the way across the top of the core liner. This will cut open the

	core liner and make it possible to acquire the soil samples inside the core liner.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Contact with impacted soils and water.	Impacted sites, during sample collection and handling.	Adverse health effects could result from ingesting, inhaling, and/or skin/eye contact with impacted soils and water.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves when collecting and handling samples. Employees will wear work gloves when handling probe rods. Work will be suspended during high wind conditions that produce large amounts of visible impacted dust.
	Hydraulic fluid and diesel.	Geoprobe®.	Employees could be exposed to hydraulic fluid and/or diesel via inhalation, ingestion, and skin/eye contact, when operating the Geoprobe®, or if equipment malfunctions resulting in adverse health effects.	Employees will wear work gloves and eye protection, if contact with hydraulic fluid/diesel is possible. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe® trailer. Cleanup materials will be disposed of according to the appropriate regulations. All components of the rig will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
	Lubricating grease.	Probing location.	Employees could be exposed to lubricating grease via ingestion and skin/eye contact when assembling probe rods resulting in adverse health effects.	Employees will wear work gloves and eye protection when assembling probe rods.

	Liquinox	Probing location.	Employees could be exposed to Liquinox via ingestion and skin/eye contact when assembling probe rods resulting in adverse health effects.	Employees will wear work gloves and eye protection when assembling probe rods.
PRESSURE	Pressurized hydraulic lines.	Geoprobe®.	Faulty pressurized hydraulic lines could burst resulting in personal injury/exposure and hydraulic fluid release.	All components of the rig will be inspected prior to and at the completion of the task.
ELECTRICAL	Defective electrical lines.	Geoprobe®.	Contact with defective electrical lines could result in personal injury.	Inspect electrical lines of the Geoprobe® prior to and at the completion of the task.
	Lightning.	All sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
MOTION	Improper body mechanics.	Assembling and handling rods/sample tubes.	Improper lifting, bending, squatting, and kneeling could result in muscle/back strains or other injuries.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder height. Two people will lift, if necessary. Employees should stretch prior to starting work and they will take breaks when necessary.

	Pinch points.	During equipment assembly and when cutting sample liners.	Employees could be exposed to hand injuries such as lacerations, punctures, cuts, and pinched fingers when assembling probe rods and sample casings, and when using the liner cutter.	Employees will wear work gloves when assembling probe rods and sample casings, using the liner cutter, and handling plastic core liners after they have been cut open. Workers will be trained on how to properly use the liner cutter.
	Flying debris.	Probing location.	Eye injuries could result from flying debris when assembling probe rods and sample casings.	Employees will wear safety glasses at all times during Geoprobe® operations.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Employees will plan their path and walk cautiously. Keep work area free of tools/rods. If conditions are wet/muddy, muck boots may be worn. Site can be cleared of snow, if applicable.
	Falling rods.	Probing location.	Heavy rods could slip off of worker's hands while carrying and assembling tool strings causing personal injury.	Employees will use work gloves when assembling and handling rods. Two workers will carry rods, if necessary. All personnel will wear steel-toe boots.
THERMAL	Cold/heat stress.	Outdoors.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia.	Training on signs and symptoms of cold/heat stress. Personnel will wear appropriate clothing when working outdoors. Employees

			Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear sunscreen, long-sleeve work shirts and long pants. Employees will also use safety glasses with tinted lenses.
BIOLOGICAL	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. All employees operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency Kill switch button.
	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies should notify their supervisor.

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Level D PPE.
APPLICABLE MSDS	MSDSs will be maintained based on site characterization and contaminants. Hydraulic fluid, diesel, Liquinox, and lubricating grease.
REQUIRED PERMITS/FORMS	Per site/project requirements.

ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-GEOPROBE-07 Operating the Geoprobe® During Probing Operations
TOOLS	
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
SAFETY AND HEALTH MANAGER	**DATE**

Revisions:

Revision	Description	Date

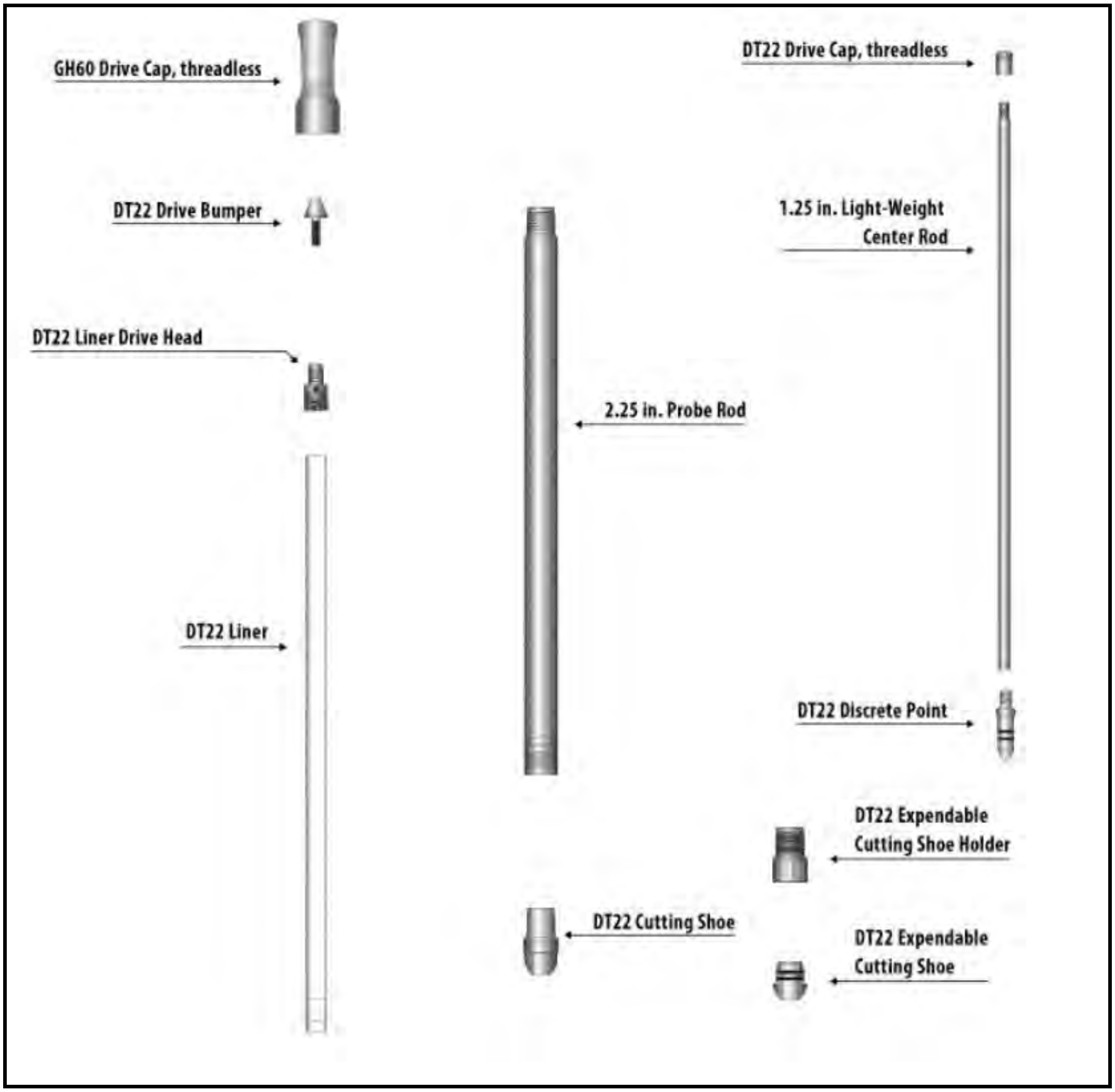

Figure 1 - The DT-22 Tool String Diagram

PURPOSE	To provide standard instructions for constructing tool strings and sampling procedures using the Geoprobe® DT-325 Dual Tube Sampling System and the 3.25-inch probe rod.
SCOPE	This practice is for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed procedure described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work performed under this Standard Operating Procedure (SOP) will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
DT-325 expendable cutting shoe tool string set up.	The procedure for operating the Geoprobe® can be reviewed in SOP-GEOPROBE-07 Operating the Geoprobe® During Probing Operations. Figure 1 depicts the DT-325 tool string diagram. The expendable cutting shoes are used to collect soil samples during probe string advancement. When soil sampling is complete, tooling or materials (e.g., monitoring wells) can be placed or constructed inside the probe rod string, leaving the expendable cutting shoe at the bottom of the probe hole as the probe rod is removed from the hole. The following instructions describe how to assemble the expendable cutting shoe tool string. Pioneer has two 3.25-inch probe rod sizes for use: the 4-foot rods and the 5-foot rods depending on project needs. 1. The expendable cutting shoe has two grooves on the neck portion of the cutting shoe. Lubricate a single O-ring with Liquinox soap solution. Place the lubricated O-ring on the top-most groove. 2. Take the expendable cutting shoe, with the O-ring installed, and push the cutting shoe into the expendable cutting shoe holder. Thread the expendable cutting shoe holder onto the female end of the 3.25-inch probe rod. 3. Prepare the soil sample sheath assembly using the following steps: • Press a DT-325 ring retainer onto the bottom end of the 2.1-inch diameter clear plastic core liner. • Slide the sample tube assembly into the sample sheath and thread the ring retainer into the sample sheath. If a core catcher is used, ensure it is on the end with the ring retainer. • Thread sheath drive head on top portion of the sample

	sheath. • Place the sample sheath assembly into the lead probe rod with the expendable cutting shoe. • Place the centering drive cap on the sheath drive head. • Place 3.25-inch drive cap on the outer probe string. • The tool string is now ready to drive and sample the first interval. 4. Drive the tool string to depth. 5. Remove outer drive cap and then the inner centering drive cap. 6. Thread the 1.25-inch Tee-handle on to the sheath drive head and pull the sample sheath from the outer rod. 7. Unthread the ring retainer to remove the plastic liner containing the soil core. Decontaminate the sample sheath and components as required and reassemble using a new plastic liner as described in step 3 above. 8. Place a four- (or five-) foot light weight center rod onto the sample drive head and lower the sampler back into the outer probe rod remaining in the ground until it seats into the outer rod assembly. This will leave a light weight center rod sticking 4 (or 5) feet above the top of the outer rod. 9. Place another outer probe rod over the light weight center rod and thread it onto the lower probe rod until the joint is tight. Tighten joint with a pipe wrench if necessary. 10. Place the inner drive cap onto the top of the light weight center rod followed by the placement of the outer drive cap over the threads of the probe rods. The tool string is now complete and ready to probe and sample the next interval. The process is repeated by adding a light weight center rod and outer probe rod each interval until final depth is achieved. Installation of a well or other equipment can now proceed.
DT-325 threaded cutting shoe tool string set up.	The threaded cutting shoes are used to collect soil samples. The fixed cutting shoe limits the size and placement of well materials, and therefore is typically used only for collecting soil cores. However, small diameter wells or piezometers can be placed through the center of the cutting shoe. 1. Thread the cutting shoe onto the female end of the DT-325 probe rod.

	2. Prepare the sample sheath assembly using the following steps: • Press a DT-325 ring retainer onto the bottom end of the 2.1-inch diameter clear plastic core liner. • Slide the sample tube assembly into the sample sheath and thread the ring retainer into the sample sheath. If a core catcher is used, ensure it is on the end with the ring retainer. • Thread sheath drive head on top portion of the sample sheath. • Place the sample sheath assembly into the lead probe rod with the threaded cutting shoe. • Place the centering drive cap on the sheath drive head. • Place 3.25-inch drive cap on the outer probe string. • The tool string is now ready to drive and sample the first interval. 3. Drive the tool string to depth. 4. Remove outer drive cap and then the inner centering drive cap. 5. Thread the 1.25-inch Tee-handle on to the sheath drive head and pull the sample sheath from the outer rod. 6. Unthread the ring retainer to remove the plastic liner containing the soil core. Decontaminate the sample sheath and components as required and reassemble using a new plastic liner as described in step 2 above. 7. Place a four- (or five-) foot light weight center rod onto the center rods or sample drive head and lower the sampler back into the outer probe rod remaining in the ground until it seats into the outer rod assembly. This will leave a light weight center rod sticking 4 (or 5) feet above the top of the outer rod. 8. Place another outer probe rod over the light weight center rod and thread it onto the lower probe rod until the joint is tight. Tighten joint with a pipe wrench if necessary. 9. Place the inner drive cap onto the top light weight center rod followed by the placement of the outer drive cap over the threads of the probe rods. The tool string is now complete and ready for probing the next interval.
DT-325 expendable point tool string set up.	The expendable points are used when collection of soil samples is not needed, but tooling or materials (e.g., monitoring wells) are to be placed or constructed through the outer rods. 1. The expendable point has two grooves on the neck portion of the

	tip. Lubricate a single O-ring with Liquinox soap solution. Place the lubricated O-ring in the upper groove. 2. Take the expendable point, with the O-ring inserted, and place the point into the expendable point holder 3. Thread the expendable point holder onto the female end of the 3.25-inch probe rod. 4. Place the outer drive cap over the threads of the probe rods. The tool string is now ready for probing. 5. Drive the probe rod the full interval. 6. Continue to add a new 3.25-inch probe rod as the probe string is advanced each interval. 7. Continue driving the 3.25-inch rods until the desired depth is reached.
Threaded point tool string set up.	The threaded point is used when collecting samples is not needed and tooling or equipment (e.g., monitoring wells) will not be placed or constructed inside the hole. 1. Thread the solid point onto the female end of the 3.25-inch probe rod. 2. Place the outer drive cap over the threads of the probe rods. The tool string is now complete and ready for probing.
Cutting the DT-325 sample liners.	1. Unfold and setup the sample table. 2. Place the aluminum sample core liner holder on the table and fasten the holder to the table with hand clamps. 3. Place the core liner that needs to be sampled in the aluminum holder tray. Place the liner so that the core catcher end of the liner slides over the sample tray retaining pin. 4. Place the DT-325 core liner cutter at the top of the core liner and pull the length of the core liner. This operation will cut the core liner and make it possible to acquire the soil samples inside the core liner.

Pulling 3.25-inch rods from the ground using threaded pull cap.	1. Thread pull cap on top of the rod string to be extracted from the ground. 2. Move Geoprobe head with rod puller into position to pull the rod. 3. Begin pulling rod out of ground until the pull cap is at full height. 4. Place rod clamp around rods at ground level and clamp tightly. 5. Relax the pull on the rods by moving the Geoprobe head down slightly, allowing the pull bar to be moved away from the pull cap. 6. Remove pull cap. 7. Remove upper rod from the rod string. 8. Replace threaded pull cap on remaining rod string and repeat the process until all the rods have been removed from the ground.
Pulling 3.25-inch rods from the ground using external rod grip system.	1. Move Geoprobe head into position to where the leaf pull plates line up on rod. If the rod was originally driven to ground level, thread a 2-foot rod on the string to extend the string, allowing the rod grip system to grab the rod string. 2. Install rod grip tool by aligning the pull pins on the head with the tool. 3. Begin pulling rods from the ground. 4. Once at the top of the pull, install the rod clamp at ground level to secure the rod string. 5. Relax the pull of the Geoprobe head and remove the rod grip tool. 6. Move the Geoprobe head back away from the rod and remove the upper rod. 7. Repeat the procedure until all rods have been removed from the ground.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated soils and water.	Contaminated sites, during sample collection and handling.	Adverse health effects could result from ingesting, inhaling, and/or skin/eye contact with contaminated soils and water.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Personnel will wear nitrile gloves when collecting and handling samples. Personnel will wear work gloves when handling probe rods. Work will be suspended during high wind conditions that produce large amounts of visible dust.
	Exposure to hydraulic fluids and diesel.	Geoprobe®.	Personnel could be exposed to hydraulic fluids and/or diesel via inhalation, ingestion, and skin/eye contact, when operating the Geoprobe®, or if equipment malfunctions resulting in adverse health effects.	Personnel will wear work gloves and eye protection, if contact with hydraulic fluids/diesel is possible. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe® trailer. Cleanup materials will be disposed of according to the appropriate regulations. All components of the Geoprobe® will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
	Lubricating grease.	Probing locations.	Personnel could be exposed to lubricating grease via ingestion and skin/eye contact when assembling probe rods resulting in adverse health effects.	Personnel will wear work gloves and eye protection when assembling probe rods.

CHEMICAL	Liquinox.	Assembling the probe rods.	Personnel could be exposed to Liquinox via ingestion and skin/eye contact when assembling probe rods resulting in adverse health effects.	Personnel will wear work gloves and eye protection when assembling probe rods.
NOISE	Elevated noise levels.	Operating the Geoprobe®.	Personnel could be exposed to elevated noise levels when operating or working near the Geoprobe® resulting in hearing damage.	The Geoprobe® operator and helper will wear double hearing protection (e.g., ear plugs and earmuffs). Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe® when possible. Hearing protection will be administered and used in accordance with the policies and procedures outlined in the Pioneer Corporate HASP.
ELECTRICAL	Defective electrical lines.	Geoprobe®.	Contact with defective electrical lines could result in serious personal injury.	Personnel will inspect the electrical lines of the Geoprobe® prior to and at the completion of the task.
	Contact with underground and/or overhead utilities.	Probing locations.	Injury, death or property damage could occur from equipment contact with underground and/or overhead utilities while operating the Geoprobe®.	Personnel will follow the underground and overhead utilities procedures as outlined in the Pioneer Corporate HASP. Personnel will avoid areas with underground and overhead utilities hazards as much as possible.
BODY MECHANICS	Improper body mechanics.	Assembling and handling rods/sample tubes.	Improper lifting, bending, squatting, and kneeling could result in muscle/back strains or other	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder’s height. Two workers will lift/handle

			injuries.	heavy items as necessary. Personnel should stretch prior to starting work and they will take breaks when necessary.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces, and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Personnel will wear work boots with good traction and ankle support. They will plan their path and walk cautiously and keep work area free of tools/rods. If conditions are wet/muddy, personnel will wear muck boots.
	Falling rods.	Probing locations.	Heavy rods could slip of worker's hands while carrying and assembling tool strings causing personal injuries.	Personnel will use work gloves when assembling and handling rods. Two workers will carry rods if necessary. All personnel will wear steel-toe boots.
WEATHER	Cold/heat stress.	Outdoor sites.	Exposure to cold climates may result in cold burns, frostbite, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on the signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors (e.g., layers and loose clothing). Personnel will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer Corporate HASP.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Personnel will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoor sites.	Personnel could be exposed to UV radiation during summer months causing sun burns, skin	Personnel will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Personnel should wear sunscreen, if necessary.

			damage, and eye damage.	
BIOLOGICAL	Plants, insects, and animals.	Outdoors.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First aid kits will be available in company vehicles. Personnel with allergies will notify their supervisor.
MECHANICAL	Pinch points.	During equipment assembly and when cutting sample liners.	Personnel could be exposed to hand injuries such as lacerations, punctures, cuts, and pinched fingers when assembling probe rods and sample casings, and when using the liner cutter.	Personnel will wear work gloves when assembling probe rods and sample casings, using the liner cutter, and handling plastic core liners after they have been cut open. Personnel will be trained on how to properly use the liner cutter.
	Flying debris.	Probing locations.	Eye injuries could result from flying debris when assembling probe rods and probe rods and sample casings, and during probing operations.	Personnel will wear safety glasses always during Geoprobe® operations.
	Moving parts of the Geoprobe®.	Geoprobe® operations.	Inadvertent contact with moving parts could result in fingers/hands becoming pinched or caught causing scrapes, cuts, and/or broken bones.	Personnel will avoid touching moving parts of the Geoprobe®. The operator and helpers will not wear loose clothing/jewelry. Personnel will know the location of all emergency shutoffs on the Geoprobe®. Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe® when possible.

PRESURE	Pressurized hydraulic lines.	Geoprobe®.	Hydraulic hoses could burst/rupture resulting in inadvertent contact with hydraulic fluid or personal injury due to being struck by hoses.	The operator will inspect the Geoprobe® and document inspections daily before starting work. The operator will also replace/repair all faulty equipment before starting work. When inspecting equipment, personnel will wear work gloves to prevent possible exposures to hydraulic fluids. Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe®.
THERMAL	Hot surfaces.	Geoprobe®.	The equipment components could become hot during Geoprobe® operations and direct contact with these components could cause skin injuries.	Personnel will avoid contact with hot surfaces, and they will wear work gloves as needed.
HUMAN FACTORS	Inexperienced and improperly trained personnel.	Sites.	Inexperienced personnel and improper training could cause incidents resulting in adverse health effects and/or property damage.	Personnel will be properly trained in the procedure described above and other applicable procedures. All personnel operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency Kill switch button.
SIMOPS	Not applicable.			
ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
REQUIRED PPE	**Personal Protective Equipment** (PPE): Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, nitrile gloves, leather gloves, and hearing protection.			
APPLICABLE SDSs	Hydraulic fluid, diesel, Liquinox, and lubricating grease. Additional Safety Data Sheets (SDSs) will be maintained based on the site characterization and contaminants.			

REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-GEOPROBE-07 Operating the Geoprobe® During Probing Operations.
TOOLS	Hand tools. Refer to Figure 1 for parts and accessories.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Ken Manchester	**05/31/2018**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman	**05/31/2018**

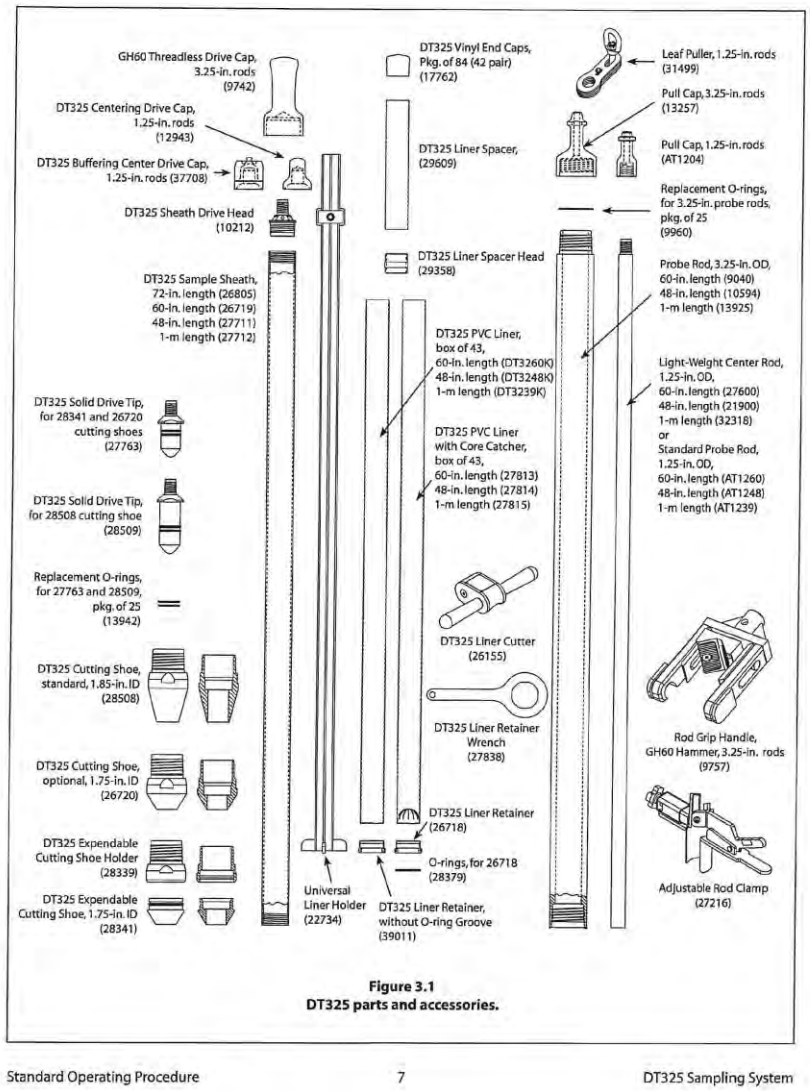

Figure 3.1
DT325 parts and accessories.

Figure 1 - The DT-325 Tool String Diagram

PURPOSE	To provide standard instructions for operating the Geoprobe® Model 66DTX during probing operations.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Probe Operating Controls	***Probe*** The Probe Control Lever (Figure 1) operates the probe cylinder (Figure 2). The probe control lever will lower and raise the probe cylinder. Place the probe control lever in the downward position to lower the probe cylinder and place the probe control lever in the upward position to raise the probe cylinder. The probe cylinder uses the static weight of the machine to force the rig tooling into the ground to either conduct sampling or install wells. ***Hammer/Rotation*** The Hammer/Rotation Control Lever (Figure 1) activates and deactivates the hammer percussion and also will allow some rotation when percussion is conducted. The Hammer/Rotation is used when the static weight of the machine is not enough force to push the tooling into the ground. Sometimes the Hammer/Rotation is helpful when sampling and not getting very good recovery just with the static weight of the rig. The rotation is generally not used much during our probing operations. ***Auger*** The Auger Control Lever (Figure 1) controls the speed and direction of the auger head. This tool is not used in our probing operations. ***Regen (Two-Speed Pull System)*** The Regen Control Switch (Figure 1) activates the regenerating probe cylinder circuit. By activating the circuit, the probe cylinder will move up and down much faster. When using this system, the probe cylinder will lose a lot of its pulling force. This switch is mostly used on shallow holes or when the end of the tool string is on deeper holes.
Probing Using Static Weight	When using static weight, the Geoprobe® only uses the weight of the unit to advance probe rods. 1. Drive and position the Model 66DTX at the desired sampling

location. Refer to SOP-GEOPROBE-04 Driving and Positioning the Geoprobe® Model 66DTX for instructions.

2. Put a magnetic bullet level on the front of the derrick on the rig (Figure 3). Make sure the derrick is level vertically. To level the derrick vertically, use the Fold Control Lever until the derrick is leveled.

3. Place the magnetic bullet level on the side of the derrick (Figure 4). Place the outriggers.

4. Set up the tool string using the desired points for the DT-22 or the DT-325 dual tube systems. Refer to SOP-GEOPROBE-05 Geoprobe® DT-22 Dual Tube Sampling System and SOP-GEOPROBE-06 Geoprobe® DT-325 Dual Tube Sampling System for tool string diagrams and set-up procedures.

5. Position the initial pipe/tool string under the probe cylinder (Figure 5). Lower the probe cylinder onto the drive head by placing the probe lever into the downward position.

CAUTION: *do not hold onto the drive cap; make sure to hold onto the pipe when lowering the probe cylinder onto the drive head. This will make sure that no appendages can be pinched between the metal.*

6. Place the magnetic bullet level on the front of the pipe (Figure 5). Use the extend lever to get the pipe level from front to back.

7. Place the magnetic bullet level on the side of the pipe (Figure 6). Use the swing lever to get the pipe level from side to side.

IMPORTANT: *ensure that the first pipe entering the ground is leveled. This will ensure there is no angle to the probe hole and will make for easier extraction when pulling the tool string out of the ground. It is best to initially check the pipe for level and then push the pipe halfway into the ground and check the level again. Do not try to force the pipe level after the first pipe has entered the ground. This will break the threads on the pipe and can break the pipe itself.*

8. When the first pipe/tool string is leveled, begin to pull the probe lever down to start pushing the rod into the ground. Stop halfway down the four-foot rod and re-level the pipe. Then continue to push the rod into the ground by pulling down on the probe lever. During static weight probing, the foot of the derrick may or may not slightly lift off of the ground. To get a feel for the machine and how hard the soil is, the operator should place their left foot on the front portion of the foot of the rig (Figure 7).

NOTE: *if the operator is recovering small soil samples, try to use the*

	hammer lever slightly to try and vibrate the soil into the sample tube. It is very unlikely that just the static weight of the rig will be able to push the rod into the ground past four to eight feet. 9. If the operator is taking cores, the next step would be to pull off the drive tooling and use the extraction "T" (Figure 8) to pull the sample out of the outside casing. 10. Place the next sample core (DT-22 system) or sample sheath (DT-325 system) into the pipe that has been driven into the ground. Before the sample core or sample sheath has been let all the way down the outer rod, make sure to screw on a piece of 1.25-inch light weight inner rod to the sample core or sample sheath (Figure 9). 11. Once the 1.25-inch light weight inner rod has been attached to the sample core or sample sheath and inserted into the outer rod, place another piece of probing pipe to the pipe that has been pushed into the ground. Thread the new piece of pipe onto the existing pipe all the way and make sure that the connection is tight. 12. Replace the drive tooling and continue to push until total depth or refusal has been reached. ***NOTE:*** *as stated before, just the static weight may not be enough to reach the total depth of the hole. Do not just use static weight if one believes they have reached refusal. Refusal is when the piping will not go into the ground anymore.*
Probing Using Percussion and Static Weight	The tool string cannot be advanced using only the static weight of the vehicle in some soil formations. In these situations, hammer percussion must be employed as described in this section. 1. Drive and position the Model 66DTX at the desired sampling location. Refer to SOP-GEOPROBE-04 Driving and Positioning the Geoprobe® Model 66DTX for instructions. 2. Put a magnetic bullet level on the front of the derrick on the rig (Figure 3). Make sure the derrick is level vertically. To level the derrick vertically, use the Fold Control Lever as stated in SOP-GEOPROBE-02 Pre-Job and Post-Job Inspection until the derrick is leveled. 3. Place the magnetic bullet level on the side of the derrick (Figure 4). Place the outriggers 4. Set up the tool string using the desired points for the DT-22 or the DT-325 dual tube systems. Refer to SOP-GEOPROBE-05 Geoprobe® DT-22 Dual Tube Sampling System and SOP-GEOPROBE-06 Geoprobe® DT-325 Dual Tube Sampling System

for tool string diagrams and set-up procedures.

5. Position the initial pipe/tool string under the probe cylinder (Figure 4). Lower the probe cylinder onto the drive head by placing the probe lever into the downward position.

CAUTION: *do not hold onto the drive cap; make sure to hold onto the pipe when lowering the probe cylinder onto the drive head. This will make sure that no appendages can be pinched between the metal.*

6. Place the magnetic bullet level on the front of the pipe (Figure 5). Use the extend lever to get the pipe level from front to back.

7. Place the magnetic bullet level on the side of the pipe (Figure 6). Use the swing lever to get the pipe level from side to side.

IMPORTANT: *ensure that the first pipe entering the ground is leveled. This will ensure there is no angle to the probe hole and will make for easier extraction when pulling the tool string out of the ground. It is best to initially check the pipe for level and then push the pipe halfway into the ground and check the level again. Do not try to force the pipe level after the first pipe has entered the ground. This will break the threads on the pipe and can break the pipe itself.*

8. When the first pipe/tool string is leveled, begin to pull the probe lever and the hammer/rotation lever down to start pushing and hammering the rod into the ground. Stop halfway down the four-foot rod and re-level the pipe. Then continue to push the rod into the ground by pulling down on the probe lever and hammer/rotation lever. During percussion probing, the foot of the derrick should be lifted roughly an inch off of the ground. To get a feel for the machine and how hard the soil is, the operator should place their left foot on the front portion of the foot of the rig (Figure 7).

NOTE: *the operator needs to make sure that the foot of the derrick comes off of the ground during percussion probing. If the foot is not coming off of the ground, the rubber bumpers (Figure 10) will melt and deteriorate. This is because not enough static weight is being applied to the tool string.*

9. If the operator is taking cores, the next step would be to pull off the drive tooling and use the extraction “T” (Figure 8) to pull the sample out of the outside casing.

10. Place the next sample core (DT-22 system) or sample sheath (DT-325 system) into the pipe that has been driven into the ground. Before the sample core or sample sheath has been let all the way down the outer rod, make sure to screw on a piece of 1.25-inch light weight inner rod to the sample core or sample sheath (Figure 9).

	11. Once the 1.25-inch light weight inner rod has been attached to the sample core or sample sheath and inserted into the outer rod, place another piece of probing pipe to the pipe that has been pushed and hammered into the ground. Thread the new piece of pipe onto the existing pipe all the way and make sure that the connection is tight. 12. Replace the drive tooling and continue to push until total depth or refusal has been reached.
Adding Probe Rods, Inner Rods, and Sample Liners or Sheaths	Probe rods must be added to the tool string to reach the desired depth below ground surface. 1. Using the probe control lever, raise the hammer assembly to its full height. 2. Using the extend lever, extend back as far as the rig will go. This will allow for easy access to the in-ground tool string and will allow for easy addition of probe rods and sampling equipment. 3. Remove the drive cap from the probe rod that was driven into the existing ground. 4. Use the extraction "T" to get the inner rods and sample liner or sample sheath out of the existing probe rod or rods. The inner rods simply thread onto each other and the sample core or sample sheath. Refer to SOP-GEOPROBE-05 to see the procedure and diagrams of how to set up the DT-22 Sample Core. Refer to SOP-GEOPROBE-06 to see the procedure and diagrams of how to set up the DT-325 Sample Sheath. 5. If retrieving cores, replace the sample core or sample sheath with a clean set and attach enough inner rod to leave an extra length of pipe (4 feet) out of the in-ground probe rod. 6. Place a new piece of probe rod over the 4 foot length of inner rod sticking out of the existing hole and thread the new probe rod to the existing probe rod in the ground. 7. Replace the drive tooling. Use the extend lever to extend the rig until the probe cylinder is above the drive cap. 8. Slowly lower the probe cylinder onto the top probe rod with the probe control lever. 9. Throttle up the engine until it is at full throttle and advance the tool string into the ground. 10. Repeat steps 1- 9 until the desired sampling depth or refusal is reached.

	IMPORTANT: *do not continue probing if the tool string meets refusal. Prolonged hammering at refusal can cause damage to the tool string.*
Pulling Probe Rods with the Pull Cap	A pull cap is used to retract probe rods from an existing bore hole, when monitoring wells are not installed in the probe rods. 1. Raise the hammer assembly just high enough to provide access to the top probe rod. 2. Remove the drive cap from the top probe rod of the tool string. 3. Attach a pull cap (Figure 10) to the top probe rod by threading the pull cap onto the probe rod. 4. Ensure that the probe foot is in contact with the ground surface. This provides support for the unit. The downward force resulting from pulling the rods may damage the unit if the foot is not supported. ***NOTE:*** *if when pulling the probe rods out of the ground the foot begins to sink into the ground, then lengths of blocking should be placed under the foot to allow for more surface area to support the force on the ground.* 5. Hold down on the probe control lever until the drive head is close to the pull cap. 6. Pull the pin (Figure 11) upward to release the extraction latch and place it around the pull cap (Figure 12). 7. Retract the probe rod by placing the probe control lever in the upward position until motion has stopped. 8. Once the probe cylinder is all the way up and the first probe rod has been retracted, place a pipe vice on the lower section of the pipe (Figure 13). A pipe vice is used so that when the extraction latch is taken off, the top piece of pipe can be unattached from the tool string without losing the rest of the tool string down the hole. 9. Lower the probe cylinder slightly so the extraction latch is free from the pull cap. Pull the extraction latch and lock it back into its locked position (Figure 14). 10. Extend the machine back in by pulling the extend lever upward. This will allow some room for unthreading pipe. 11. Place the section of pipe that was taken off of the tool string to the side to be later decontaminated.

	12. Extend the rig to where the cylinder is above the in-ground tool string. 13. Repeat steps 3 through 12 until the entire tool string has been extracted from the ground.
Pulling Probe Rods with the Rod Grip Pull System	The rod grip pull system is used when installing monitoring wells and other applications when the inside of the tool string needs to be available during extraction of the probe rods. There are three handle assemblies and jaws to accommodate the various rod sizes: 1.0-inch, 1.25-inch, 2.125-inch, and 3.25-inch (Figure 15). ***Pulling Probe Rods*** In order to pull with this system, there must be enough exposed probe rod above the ground surface to allow the puller jaws to engage the outside of the rod. Approximately 18 inches of exposed rod is needed. If the tool string is driven to far and the puller cannot fully engage the top probe rod, simply add another rod to the tool string and reattach the handle assembly. ***IMPORTANT:*** *it is very important that the puller jaws never grip over the threaded section of a probe rod. Severe damage to the threads will result. Furthermore, avoid placing the puller near rod joints as gripping is not as effective at this location and rod deformation can occur.* 1. Lower the extraction latch so it will not bind up the pipe when extracting with the rod grips. 2. Position the hammer with the jaws directly behind the top probe rod and below the threads (Figure 16). Take the appropriate handle assembly (according to rod diameter) and orientate the jaw cutout toward the probe rod as shown in Figure 17. 3. Hook the handle over the socket head cap screws on each side of the probe cylinder (Figure 18). 4. To start pulling, lower the end of the handle assembly and raise the probe cylinder. This tightly clamps the jaws of the handle and probe cylinder around the probe rod. If slipping occurs, step on the end of the handle assembly to encourage the gripping action. 5. Once fully raised, place a pipe vice on top of the probe rod below the retracted rod connection and slightly lower the probe cylinder to release the pressure on the probe rod. Lift the end of the handle to rotate the assembly on the cap screws. This moves the handle jaw away from the probe rod and disengages the puller. The probe cylinder can now be lowered to pull another section of rod. 6. Repeat steps 2 through 5 until the in-hole tool string is fully

	extracted.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Contact with impacted soils and water.	Impacted sites, during sample collection and handling.	Adverse health effects could result from ingesting, inhaling, and/or skin/eye contact with impacted soils and water.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves when collecting and handling samples. Employees will wear work gloves when handling probe rods. Work will be suspended during high wind conditions that produce large amounts of visible impacted dust.
	Hydraulic fluid and diesel.	Geoprobe®.	Employees could be exposed to hydraulic fluid and/or diesel via inhalation, ingestion, and skin/eye contact, when operating the Geoprobe®, or if equipment malfunctions resulting in adverse health effects.	Employees will wear work gloves and eye protection, if contact with hydraulic fluid/diesel is possible. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe® trailer. Cleanup materials will be disposed of according to the appropriate regulations. All components of the rig will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
	Lubricating grease.	Probing location.	Employees could be exposed to lubricating grease via ingestion and skin/eye contact when assembling probe rods resulting in adverse health effects.	Employees will wear work gloves and eye protection when assembling probe rods.

PRESSURE	Pressurized hydraulic lines.	Geoprobe®.	Faulty pressurized hydraulic lines could burst resulting in personal injury/exposure and hydraulic fluid release.	All components of the rig will be inspected prior to and at the completion of the task.
	Excessive noise levels.	Geoprobe®.	Employees could be exposed to excessive noise levels when operating the Geoprobe® resulting in irritability, decreased concentration, and noise-induced hearing loss.	The Geoprobe® operator and helper will wear double hearing protection (i.e., earplugs and earmuffs). Non-essential personnel will wear single hearing protection and maintain a 20-foot buffer zone around the rig.
ELECTRICAL	Defective electrical lines.	Geoprobe®.	Contact with defective electrical lines could result in personal injury.	Inspect electrical lines of the Geoprobe® prior to and at the completion of the task.
	Lightning.	All sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
	Contact with overhead utilities.	Probing location.	Injury, death, or property damage could occur from contact with overhead utilities when the hammer assembly is raised to its highest position.	If overhead hazards are present, established overhead utility procedures will be followed. Probe locations will be moved to avoid working around overhead utilities. Employees will maintain the required minimal radial clearance distances based on voltage when working around overhead lines.

	Contact with underground utilities.	Probing location.	Injury, death or property damage could occur from contact with underground utilities when geoprobing.	Prior to starting work, employees will call for a utility locate (i.e., call 811). If underground utilities are present, established underground utility procedures will be followed. Probe locations will be moved to avoid working around underground utilities.
MOTION	Geoprobe® shifting.	Probing location, when probing with percussion and working on a sloped surface.	Personal injury and equipment damage could occur if the Geoprobe® shifts while probing with percussion and when working on a sloped surface.	When probing with percussion, do not raise the machine foot more than approximately 6 inches off the ground or the vehicle may become unstable and shift. When working on a sloped surface, position the rig so that it is facing upslope. In the event that the probe unit loses stability, it will roll away from the operator without causing injury.
	Struck by the Geoprobe®.	Operating the Geoprobe®.	Personnel could be injured if struck by the Geoprobe®.	Non-essential personnel will maintain a 20-foot buffer zone around the rig.
	Improper body mechanics.	Assembling, handling, and retrieving rods/sample tubes.	Improper lifting, bending, squatting, and kneeling could result in muscle/back strains or other injuries.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder height. Two people will lift, if necessary. Employees will also use good body mechanics when retrieving rods/sample tubes: bend knees, lean slightly away from the object, keep back and wrists straight, use legs to move the objects. Employees should stretch prior

				to starting work and they will take breaks when necessary.
	Contact with rotating and moving parts of the Geoprobe®.	Operating the Geoprobe®.	Fingers/hands could become pinched or caught in moving/rotating parts of the Geoprobe® resulting in cuts, scrapes, and/or broken bones.	Employees will not touch moving/rotating parts of the rig. Personnel will tie back long hair and will not wear loose clothing when operating the machine. Work gloves are required when operating the rig. Operators will stand to the control side of the machine, clear of the probe foot and derrick, while operating the controls. Personnel will never reach across the probe assembly to manipulate the machine controls. All employees on site will be familiar with the basic controls of the machine including the Emergency Kill switch button.
	Pinch points.	During equipment assembly, advancing the Geoprobe®, and extracting probe rods.	Employees could be exposed to hand injuries such as lacerations, punctures, cuts, and pinched fingers when assembling probe rods and sample casings, pulling probe rods and sampling devices with the hammer latch and/or the rod grip pull assembly, and when the Geoprobe hammer is in motion.	Employees will always wear work gloves when operating the Geoprobe® and handling its components. Employees will never place their hands on top of the tool string while raising or lowering the hammer. Workers will not place thumb or fingers between latch and hammer when raising latch to pull probe rods and sampling devices from the ground. Grind or file sharp burrs that can be developed on the outside of probe rods if the rod grip puller is allowed to slip during tool retrieval.

	Flying debris.	Probing location.	Eye injuries could result from flying debris when driving tool strings into the ground.	Employees will wear safety glasses at all times during Geoprobe® operations.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Employees will plan their path and walk cautiously. Keep work area free of tools/rods. If conditions are wet/muddy, muck boots may be worn. Site can be cleared of snow, if applicable.
	Falling rods.	Probing location.	Heavy rods could fall off of the Geoprobe® rig or slip off of the worker's hand causing personal injury.	Before probing begins, the operator will ensure that the rods are properly secured to the rig. Employees will use work gloves when handling rods. Two workers will carry rods, if necessary. All personnel will wear steel-toe boots.
THERMAL	Contact with hot drive head and caps.	Probing location.	The drive head and caps can become hot during probing operations and direct contact with these components could cause skin injuries.	Employees will let the drive head and caps cool down before removing them from the tool string. Workers will also wear work gloves when handling these components.
	Cold/heat stress.	Outdoors.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia.	Training on signs and symptoms of cold/heat stress. Personnel will wear appropriate clothing when working outdoors. Employees

			Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear sunscreen, long-sleeve work shirts and long pants. Employees will also use safety glasses with tinted lenses.
BIOLOGICAL	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. All employees operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency Kill switch button.
	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies should notify their supervisor.

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Level D PPE, earplugs, and earmuffs.
APPLICABLE MSDS	MSDSs will be maintained based on site characterization and contaminants. Hydraulic fluid, diesel, and lubricating grease.
REQUIRED PERMITS/FORMS	Per site/project requirements.

ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-GEOPROBE-04 Driving and Positioning the Geoprobe® Model 66DTX SOP-GEOPROBE-05 Geoprobe® DT-22 Dual Tube Sampling System SOP-GEOPROBE-06 Geoprobe® DT-325 Dual Tube Sampling System
TOOLS	
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	DATE
SAFETY AND HEALTH MANAGER	DATE

Revisions:

Revision	Description	Date

PURPOSE	The purpose of this SOP is to provide instructions to install a permanent, small-diameter groundwater monitoring well that can be used to collect water quality samples, conduct hydrologic and pressure measurements, or perform any other sampling event that does not require large amounts of water over a short period of time (e.g., flow rate > 1 liter/minute). These methods meet or exceed the specifications discussed for direct push installation of permanent monitoring wells with prepacked screens in the U.S. Environmental Protection Agency's guidance document, *Expedited Site Assessment Tools For Underground Storage Tank Sites*, (EPA, 1997) and ASTM Standards *D 6724* (ASTM, 2002) and *D 6725* (ASTM, 2002).
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.
DEFINITIONS	**Geoprobe® Direct Push Machine:** a vehicle-mounted, hydraulically-powered machine that uses static force and percussion to advance small-diameter sampling tools into the subsurface for collecting soil core, soil gas, or ground water samples. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling, soil conductivity and contaminant logging, grouting, materials injection, and to install small-diameter permanent monitoring wells or temporary piezometers. **0.5-inch x 1.4-inch OD Prepacked Well Screen (0.5-inch prepack):** an assembly consisting of a slotted PVC pipe surrounded by environmental grade sand contained within a stainless steel wire mesh cylinder. The inner component of the prepacked screen is a flush-threaded, 0.5-inch Schedule 80 PVC pipe with 0.01-inch (0.25 mm) slots. Stainless steel wire mesh with a pore size of 0.011 inches (0.28 mm) makes up the outer component of the prepack. The space between the inner slotted pipe and outer wire mesh is filled with 20/40 mesh silica sand. Geoprobe® 0.5-inch x 1.4-inch prepacks are available in 3-foot and 5-foot sections and have an outside diameter of 1.4 inches (36 mm) and a nominal inside diameter of 0.5 inches (13 mm). **0.75-inch x 1.4-inch OD Prepacked Well Screen (0.75-inch prepack):** an assembly consisting of a slotted PVC pipe surrounded by environmental grade sand contained within a stainless steel wire mesh cylinder. The inner component of the prepacked screen is a flush-threaded, 0.75-inch Schedule 40 PVC pipe with 0.01-inch (0.25 mm) slots. Stainless steel wire mesh with a pore size of 0.011 inches (0.28 mm) makes up the outer component of the prepack. The space between the inner slotted pipe and outer wire mesh is filled with 20/40 mesh silica sand. Geoprobe 0.75-inch x 1.4-inch prepacks are available in 3-foot and 5-foot sections and have an outside diameter of 1.4 inches (36 mm) and a nominal inside diameter of 0.75 inches (19 mm).

DISCUSSION

Conventional monitoring wells are typically constructed through hollow stem augers by lowering slotted PVC pipe (screen) to depth on the leading end of a string of threaded PVC riser pipe. A filter pack is then installed by pouring clean sand of known particle size through the tool string annulus until the slotted section of the PVC pipe is sufficiently covered.

Installing the entire filter pack through the tool string annulus becomes a delicate and time-consuming process when performed with small-diameter direct push tooling. Sand must be poured very slowly in order to avoid bridging between the riser pipe and probe rod. When bridging does occur, considerable time can be lost in attempting to dislodge the sand or possibly pulling the tool string and starting over.

Prepacked screens decrease the volume of loose sand required for well installation as each screen assembly includes the necessary sand filter pack. Sand must still be delivered through the casing annulus to provide a minimum 2-foot grout barrier, but this volume is significantly less than for the entire screened interval.

The procedures outlined in this document describe construction of a permanent groundwater monitoring well using Geoprobe® 2.125-inch (54 mm) outside diameter (OD) probe rods and 1.4-inch OD prepacked screens. Geoprobe®1.4-inch prepacks are available with either nominal 0.5-inch schedule 80 or 0.75-inch schedule 40 PVC components. Further options include running lengths of 3 and 5 feet for both 0.5- and 0.75-inch prepacks.

Installation of a prepack monitoring well begins by advancing 2.125-inch (54 mm) outside diameter (OD)probe rods to depth with a Geoprobe® direct push machine. Prepacked screen(s) are then assembled and installed through the 1.5-inch (38 mm) inside diameter (ID) of the probe rods using corresponding 0.5-inch schedule 80 or 0.75-inch schedule 40 PVC riser (Fig. 2.1-A).

The prepack tool string is attached to an expandable anchor point with a locking connector that is threaded to the bottom of the leading screen. Once the connector is locked onto the anchor point, the rod string is slowly retracted until the lower end of the rods is approximately 3 feet above the top prepack.

Regulations generally require a minimum 2-foot grout barrier above the top prepack (Fig. 2.1-B) to avoid contaminating the well screens with bentonite or cement during installation. In some instances, natural formation collapse will provide the required barrier. If the formation is stable and does not collapse around the riser as the rod string is retracted, environmental grade 20/40 mesh sand may be installed through the probe rods to provide the minimum 2-foot grout barrier.

Granular bentonite or bentonite slurry is then installed in the annulus to form a well seal (Fig. 2.1-B). A high-pressure grout pump (Geoprobe® Model GS1000 or GS500) may be used to tremie high-solids bentonite slurry or neat cement grout to fill the well annulus as the probe rods are retracted (Fig. 2.1-B). The grout mixture must be installed with a tremie tube from the bottom up to accomplish a tight seal without voids to meet regulatory requirements.

In certain formation conditions, the prepacked screens may bind inside the probe rods as the rods are retracted. This is most common in sandy formations sometimes called flowing or heaving sands. This binding can generally be overcome by lowering extension rods down the inside of the well riser and gently, but firmly, tapping the extension rods against the base of the well as the rods are slowly retracted. If the binding persists, clean tap water or distilled water may be poured down the annulus of the rods to increase the hydraulic head inside the well. This, combined with the use of the extension rods, will free up the prepacked screen and allow for proper emplacement.

Once the well is set, conventional flush-mount or aboveground well protection can be installed to prevent tampering or damage to the well head (Fig. 2.1-B). These wells can be sampled by several available methods (bladder pump, peristaltic pump, mini-bailer, Geoprobe® tubing check valve, etc.) to obtain high integrity water quality samples. These wells also provide accurate water level measurements and can be used as observation wells during aquifer pump tests.

When installed properly, these small-diameter wells generally meet regulatory requirements for a permanent monitoring well. While a detailed installation procedure is given in this document, it is by no means totally inclusive. **Always check local regulatory requirements and modify the well installation procedure accordingly**. These methods meet or exceed the specifications discussed for direct push installation of permanent monitoring wells with prepacked screens in the U.S. Environmental Protection Agency's guidance document, *Expedited Site Assessment Tools For Underground Storage Tank Sites,* (EPA, 1997) and ASTM Standards D 6724 (ASTM, 2002) and *D 6725* (ASTM, 2002).

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Anchoring the Well Assembly	In this portion of the well installation procedure, an expandable anchor point is driven to depth on the end of a 2.125-inch (54 mm) OD probe rod string (Fig. 4.1). A prepacked screen assembly is inserted into the I.D. of the rod string with 5-foot (1.5 m) sections of PVC riser pipe (Fig. 4.2). The screens and riser pipe are attached to the

anchor point via a snap-lock connector.

1. If the monitoring well is to have a flush-mount finish, it is a good practice to prepare a hole large enough to accept a standard well protector before driving the probe rods.

2. Move the Geoprobe® direct push machine into position over the proposed monitoring well location. Unfold the probe and place in the proper probing position as shown in the unit Owner's Manual. Access to the top of the probe rods will be required. It is therefore important to allow room for some derrick retraction when placing the unit in the probing position.

3. Referring to Figure 4.3, place an O-ring in the groove of a 2.125-inch Expendable Anchor Point (GW2040). Insert the point into the unthreaded end of a 2.125-inch Expendable Point Holder. Note that expendable point holders are available in lengths of 36 inches/0.9 meters (AT2110), 48 inches/1.2 meters (AT2111), or 60 inches/1.5 meters (AT2112).

4. Attach a 2.125-inch Drive Cap (AT2101) to the threaded end of the point holder (Fig. 4.3).

5. Place the extendable point holder under the probe hammer in the driving position (refer to unit Owner's Manual). Drive the point holder into the ground utilizing percussion if necessary. It is important that the rod string is driven as straight as possible to provide a plumb monitoring well. If the point holder is not straight, pull the assembly and start over with Step 2.

6. Remove the drive cap from the expendable point holder. Install an O-ring (AT2100R) on the point holder in the groove located at the base of the male threads (Fig. 4.4).

Note: the operator may choose to lubricate the O-ring with a small amount of clean water. Lubricating the O-ring makes it easier to threat the probe rods together and nearly eliminate torn O-rings. A small spray bottle works well for applying the water.

7. Thread a 2.125-inch Probe Rod (AT2136, AT2139, AT2148, or AT2160) onto the expendable point holder. Place the drive cap on the probe rod and advance the rod string.

8. Remove the drive cap and install an O-ring (AT2100R) at the base of the male threads of the probe rod (Fig. 4.4). Add another probe rod and replace the drive cap. Once again, advance the rod string.

9. Repeat Step 8 until the end of the rod string is 4 inches (102 mm) below the

bottom of the desired screen interval. The additional depth allows for the connection between the expendable anchor point and screen assembly. The top probe rod must also extend at least 1 foot (25 mm) above the ground surface to allow room for the rod grip puller later in this procedure. Move the probe foot back to provide access to the top of the rod string.

10. With the probe rods and anchor point drive to the proper depth, the next step is to deploy the screen(s) and riser pipe. Thread together 1.4-inch OD prepack sections to achieve the desired screen interval. As shown in Figure 4.5, 1.4-inch OD prepacks are available with 0.5-inch Schedule 80 PVC or 0.75-inch Schedule 40 PVC components and in lengths of 3 or 5 feet (0.9 or 1.5 m). O-rings (GW430R) can be installed between the screen sections if desired.

11. Thread a Snap-look Connector (0.5-inch, GW2030 or 0.75-inch 17469) into the female end of the assembled prepacks (Fig. 4.5). An O-ring can be placed on the male threads of the connector if desired.

12. Insert the screen assembly into the probe rod string with the connector facing toward the bottom of the rod as shown in Figure 4.2.

13. With the assistance of a second person, attach 5-foot (1.5 m) sections of 0.5-inch Schedule 80 or 0.75-inch Schedule 40 PVC Riser (GW2050 or 11747) to the top of the screen assembly. O-rings are required at each riser joint to prevent groundwater from seeping into the well from above the desired monitoring interval. Continue adding riser sections until the assembly reaches the bottom on the rods (Fig. 4.2). At least 1 foot (0.3 m) of riser should extend past the top probe rod.

14. Install a PVC top cap or locking well plug on the top riser (Figure 4.5). If using the vinyl cap, secure the cap with two wraps of duct tape or electrical tape.

15. Raise the screen and riser assembly a few inches and then quickly lower it onto the expendable anchor point. This should force the snap-lock connector over the mushroomed tip of the anchor (Fig. 4.6). Gently pull up the riser to ensure that the connector and anchor are firmly attached. Approximately 0.25 inches (6 mm) of play is normal.

16. It is now time to pull up the probe rods from around the well screen and riser. Reposition the probe unit so that the Rod Grip Puller can be attached to the rod string.

17. Retract the rod string the length of the screens plus an additional 3 feet (1 m). While pulling the rods, observe whether the PVC risers stay in place or move up with the rods.

	a. If the risers stay in place, stable formation conditions are present. Continue retracting the rods to the depth specified above. Go to Section "Sand Pack and Grout Barrier." b. If the risers move up with the probe rods, have a second person hold it in place while putting up the rods. An additional section of PVC riser may be helpful. Once the probe rods have cleared the anchor point and part of the screen, the screen and riser assembly should stop raising with the rods. Continue retracting to the depth specified above. Go to Section "Sand Pack and Grout Barrier." c. If the risers continue to move up with the probe rods and cannot be held in place by hand, the anchor point is most likely located in heaving sands. Extension rods are now required. (Refer to Figure 4.6 for an illustration of extension rod accessories.) d. Place a Screen Push Adapter (GW 1535) on the end of an Extension Rod. Insert the adapter and extension rod into the PVC riser and hold by hand or with an Extension Rod Jig (AT690). Attach additional extension rods with Extension Rod Couplers (AT68) or Extension Rod Quick Links (AT694K) until the push adapter contacts the bottom of the screens (Fig. 4.8). Place an Extension Rod Handle (AT69) on the top extension rod after leaving 3 to 4 feet (1 to 1.2 m) of extra height above the last probe rod. e. Slowly retract the probe rods while another person pushes and taps on the screen bottom with the extension rods (Fig. 4.8). To ensure proper placement of the screen interval and prevent damage to the well, be careful not to get ahead while pulling the probe rods. The risers should stay in place once the probe rods are withdrawn past the screens. Retrieve the extension rods. Place the cap back on the top riser and secure the cap with duct tape if necessary.
Sand Pack and Grout Barrier	The natural formation will sometimes collapse around the well screens as the probe rod string is withdrawn. This provides an effective barrier between the screens and grout material used to seal the well annulus. If the formation does not collapse, a sand barrier must be placed from the surface. This portion of the well installation procedure is important because an inadequate barrier will allow grout to reach the well screens. Nonrepresentative samples and retarded groundwater flow into the well may result from grout intrusion. 1. Using a Water Level Sounder (GW 1200) or flat tape measure, determine the depth from the top of the PVC riser to the bottom of the annulus between the riser and probe rods. Two scenarios are possible: a. Measured depth is 2 to 3 feet (0.6 to 0.9 m) less than riser length. This indicates that unstable conditions have resulted in formation collapse. A

natural grout barrier has formed as material collapsed around the PVC riser when the probe rods were retracted. This commonly occurs in heaving sands. No further action is required. Proceed to Section "Bentonite Seal Above Screen" and perform Step 2 (for unstable formations).

b. Measured depth is equal to or greater than riser length. This indicates that stable conditions are present and the cohesive formation did not collapse. The probe hole has remained open and void space exists between the riser (and possibly the screen) and formation material. Clean sand must be placed downhole to provide a suitable grout barrier. Continue with Step 2 below.

2. Begin slowly pouring 20/40 mesh sand down the annulus between the PVC riser and probe rod string. Reduce spillage by using a funnel or flexible container as shown in Figure 4.8. Add approximately 2.0 liters of sand for each 3-foot (1 m) screen section or 3.25 liters of sand for each 5-foot (1.5 m) screen, plus 1.75 – 2.0 liters for a minimum 2-foot (0.6 m) layer of sand above the top screen section.

Note: the sand volumes specified above assume maximum annular space where no formation collapse has occurred. Actual volumes may be less in field conditions.

3. Measure the annulus depth after each 1.0 – 1.5 liters of sand. The sand may not fall all the way past the screens due to the tight annulus and possible water intrusion. This is acceptable, however, since the prepacked screens do not require the addition of sand. The important thing is that a sand barrier is provided above the screens.

4. Sand may also bridge within the annulus between the risers and probe rods and consequently fail to reach total depth (Fig. 4.9). This most likely occurs when the sand contacts the water inside the probe rods during well installations below the water table. Wet probe rods also contribute to sand bridging. If the annulus is open, skip to Section "Bentonite Seal Above Screen," Step 1. If bridging is evident, continue with Step 5 below.

5. In case of a sand bridge above the screens (wet rods, high water table, etc.), insert clean extension rods into the well annulus to break up the sand (Fig. 4.9). Simultaneously retracting the probe rods usually helps. Check annulus depth again. If sand is no longer bridged, proceed to Section "Bentonite Seal Above Screen." If bridging is still evident, continue with Step 6 below.

6. If the sand bridge cannot be broken up with extension rods, inject a small amount of clean water into the annulus. This is accomplished with a Geoprobe® Model GS1000 or GS500 Grout Machine and 3/8-inch (9.5 mm) OD nylon tubing

	(11633). Simply insert the nylon tubing down the well annulus until the sand bridge is contacted. Attach the tubing to the grout machine and pump up to one gallon of clean water while moving the tubing up and down. The jetting action of the water will loosen and remove the sand bridge. Check annulus depth again. The distance should be 2 to 3 feet (0.6 to 0.9 m) less than the riser length when the sand barrier is completed. Proceed with Section "Bentonite Seal Above Screen."
Bentonite Seal Above Screen	Bentonite is a clay material which exhibits very low permeability when hydrated. When properly placed, bentonite can prevent contaminants from moving into the well screens from above the desired monitoring interval. The seal is formed either by pouring granular bentonite into the annulus from the ground surface, or by injecting a high-solids bentonite slurry directly above the grout barrier. The use of bentonite chips is limited to cases in which the top of the screen ends above the water table (no water is present in the probe rods). Whichever method is used, at least 2 feet (0.6 m) of bentonite must be placed above the sand pack. 1. **(Stable Formation)** Granular bentonite is recommended if the following conditions are met: i. Top of screen interval is above the water table. ii. Formation remained open when probe rods were retracted. iii. Bridging was not encountered while installing the sand pack and grout barrier in Section "Sand Pack and Grout Barrier." a. Withdraw the probe rod string another 3 to 4 feet (0.9 to 1 m) and ensure that the PVC riser does not rise with rods. It is important that the bottom of the rod string is above the proposed seal interval. If positioned too low, dry bentonite will backup into the expendable point holder. Bridging then results if moisture is present inside the probe rods. b. Pour approximately 1.5 liters of granular bentonite between the probe rods and PVC riser as was done with the sand in Section "Sand Pack and Grout Barrier." c. Measure the riser depth to the bottom of the annulus. The distance should now equal the installed riser length minus the minimum 2 feet (0.6 m) of sand pack and 2 feet (0.6 m) of bentonite seal. As was stated with the sand pack, if the measured depth is significantly less than expected, the bentonite has more than likely bridged somewhere along the rod string. A procedure similar to that identified for bridged sand (Section "Sand Pack and Grout Barrier," Steps 5 and 6) may be utilized to dislodge the granular bentonite. d. Once it has been determined that the bentonite seal is properly emplaced, add 1 liter of clean water to hydrate the dry bentonite according to regulations. This is not necessary if water was used to clear

	bridged bentonite. 2. **(Unstable Formation)** A grout machine is required to install the bentonite seal if the formation collapsed when the roads were retracted or the sand bridged when installing the grout barrier. The pump is able to supply a high-solids bentonite slurry under sufficient pressure to displace formation fluids. Void places often develop when poured (gravity installed) granular bentonite is used under this conditions, resulting in an inadequate annular seal. Wet rods will often lead to bridging problems as well. a. Mix 1 gallon (3.8 L) of high-solids bentonite (20 to 25 percent by dry weight) and place in the hopper of the grout machine. b. Insert 3/8-inch nylon tubing (see note below) to the bottom of the annulus between the probe rods and well riser. Leaving at least 15 feet (5 m) extending from the top of the rod string, connect the tubing to the grout machine. This extra length will allow rod extraction later in the procedure. <u>Note:</u> the side-port tremie method is recommended to prevent intrusion of grout into the sand barrier. To accomplish side-port discharge of grout, cut a notch approximately one inch up from the leading end of the tubing and then close the leading end with a threaded plug of suitable size. c. Activate the grout pump and fill the tremie tube with bentonite. Begin slowly pulling the rod string approximately 3 feet (1 m) while operating the pump (Fig. 4.10). This will place bentonite in the void left by the retracted rods before it is filled by the collapsing formation. Continue to watch that the PVC riser does not come up with the rod string. When removing the retracted probe rod, slide the rod over the nylon tubing and place it on the ground next to the grout machine. This eliminates cutting and reattaching the tubing for each rod removed from the string. Take care not to “kink” the tubing during this process as it will create a weak spot in the tubing which may burst when pressure is applied. d. Measure the annulus depth to ensure that at least 2 feet (0.6 m) of bentonite was delivered. Pump additional bentonite slurry if needed.
Grouting Well Annulus	The placement of grout material within the remaining well annulus provides additional protection from vertical contaminant migration. Most grout mixes are composed of neat cement, high-solids bentonite slurry, or a combination of cement and bentonite. Such mixes must be delivered with a high-pressure grout pump. When stable formations exist, the well may be sealed by pouring dry granular bentonite directly into the annulus from the ground surface. Consult the appropriate regulatory agency to determine approved grouting methods.

This section presents the procedure for grouting the well annulus with the Geoprobe® Model GS1000 or GS500 Grout Machines. Refer to Figure 4.11 as needed.

1. Mix an appropriate amount of grout material and place it in the hopper on the grout machine. (Refer to the Geoprobe® Yellow Field Book for tables on volume requirements.)

Note: it is recommended that an additional 25 to 30 percent of the calculated annulus volume is included in the total grout volume. This allows for material that is left in the grout hose and tubing or moves into the formation during pumping. An approximate range is 0.25 to 0.30 gallons (0.9 to 1.1 L) of grout for each foot of riser below ground surface.

2. A side-port tremie tube may be made from a roll of 3/8-inch OD Nylon Tubing (11633) by cutting a notch in the side of the tubing approximately 1 inch (25 mm) up from the discharge end. Thread a bolt or screw of suitable diameter into the end of the tubing so that pumped grout is forced out through the notch in a side-discharge manner.

Insert the side-port tremie tube into the well annulus until the leading end of the tube reaches the top of the bentonite seal. At least 15 feet (5 m) of tubing should extend from the top of the rod string. This extra length allows rod extraction with the tubing attached to the pump.

3. Attach the tubing to the grout machine and begin pumping. If the bentonite seal was below the water table (deep well installation), water will be displaced and flow from the probe rods as the annulus is filled with grout. Continue operating the pump until undiluted grout flows from the top probe rod.

4. Reposition the direct push machine and prepare to pull rods.

5. Begin pulling the probe rods while continuing to pump grout. Match the pulling speed to grout flow so that the rods remain filled to the ground surface. This maintains hydraulic head within the probe rods and ensures that the space left by the withdrawn rods is completely filled with grout.

Note: slide the probe rods over the nylon tubing and place neatly on the ground next to the grout machine. **Be careful not to pinch or bind the tubing as this forms weak spots which may burst when pressure is applied.**

Note: try to avoid filling the upper 12 inches (305 mm) of well annulus with grout when pulling the expendable point holder. This will make for cleaner well protector installation.

	6. When all probe rods have been retrieved and the well is adequately grouted, unstring the tremie tube and begin cleanup. It is important to promptly clean the probe rods, grout machine, and accessories. This is especially true of cement mixes as they quickly set up and are difficult to remove once dried.
Surface Cover/Well Protection	A surface cover protects the PVC well riser from damage and tampering. Although aboveground and flush-mount well covers may be used, most Geoprobe® prepack monitoring wells have been installed with flush-mount covers (Fig. 4.12). Consult the project planners and/or appropriate regulators to determine the approved well cover configuration for your specific application. 1. In order to fit under a flush-mount cover, the top of the well riser must be below the ground surface. Place the well cover over the riser to mark the cover diameter. Remove the cover and excavate the soil around the well head to install the protector. 2. The top of the riser should be located several inches above the bottom of the hole (but below the adjacent ground surface) before installation of the well cover. If a riser joint is near this level, the operator may choose to unthread the top riser and adjust the depth of the hole to fit the riser height. Most prepack installations will instead require trimming the top riser to the appropriate height with PVC cutters. <u>Note:</u> do not cut off the riser with a hacksaw as cuttings may fall down into the screens. 3. In most areas, regulations specify that a locking plug be installed on the top riser of permanent monitoring wells. Insert a locking well plug into the riser and tighten the hex bolt with a ½-inch T-handle wrench or nut driver until the cap fits snugly. 4. Position the well cover so that it is centered over the well riser. Provide at least 0.5 inches (13 mm) of space between the top of the locking plug and bottom of the well cover lid. If flush-mount protection is used, install the cover slightly above grade to prevent ponding of runoff water at the well head. 5. Support the well cover by installing a concrete pad according to project requirements. Pads are commonly square-shaped with a thickness of 4 inches (102 mm) and sides measuring 24 inches (610 mm) or greater. Finish the pad so that the edges slope away from the center to prevent ponding of surface water on the well cover. 6. Fill the inside of the well cover with sand up to approximately 2 to 3 inches (51

	to 76 mm) from the top of the riser and locking plug.
Well Development	"The development serves to remove the finer grained material from the well screen and filter pack that may otherwise interfere with water quality analyses, restore groundwater properties disturbed during the (probing) process, and to improve the hydraulic characteristics of the filter pack and hydraulic communication between the well and the hydrologic unit adjacent to the well screen." (ASTM D 5092). The two most common methods of well development are bailing or pumping (purging) and mechanical surging. **Purging** involves removing at least three well volumes of water with either a Tubing Bottom Check Valve (GW42) or a Stainless Steel Mini-Bailer Assembly (GW41). Include the entire 2.125-inch (54 mm) diameter of disturbed soil at the screen interval when calculating the well volume. **Mechanical Surging** utilizes a surge block or swab which is attached to extension rods and lowered inside the riser to the screen interval. The extension rods and surge block are moved up and down, forcing water into and out of the screen. A tubing bottom check valve or peristaltic pump is then used to remove the water and loosened sediments (Figure 4.13). **Note:** mechanical surging may damage the well screen and/or reduce groundwater flow across the filter pack if performed incorrectly or under improper conditions. Refer to ASTM D 5521. "Standard Guide for Development of Groundwater Monitoring Wells in Granular Aquifers" for a detailed discussion of mechanical surging. **Fine Grained Formations:** many times field conditions or regulations require us to install monitoring wells in fine-grained formations that would not be considered a true aquifer. Development in these conditions is difficult at best. There are various development methods that may be useful depending on the specific grain size distribution of the formation. In formations with a good proportion of sand, using a rod brush slightly larger than the ID of the well as a swab may help in surging the well without clogging the filter pack. Caution is required. Adding water to slow-yielding wells may also help to loosen fines and improve recharge when swabbing. Purging wells in fine-grained formations with a peristaltic pump or bladder pump may offer the best means of development as high-energy surging can clog the screens. For more information on this topic request the Geoprobe® bulletin titled *Groundwater Quality and Turbidity vs. Low Flow.* Development should continue until representative water is obtained and natural flow is established into the well. Previously, representative water was defined primarily on the basis of consistent pH, specific conductance, temperature

	measurements, and visual clarity (ASTM D 5092). To meet the more stringent requirements of the low-flow sampling protocol (EPA 1996), monitoring of additional parameters such as dissolved oxygen (DO) and oxidation/reduction potential (ORP or Eh), and quantitative measurement of turbidity may be required.
Sample Collection	As the federal EPA and more state agencies are recommending or requiring use of the "low-flow" sampling protocol (EPA 1996), the ability to sample small-diameter, direct push (DP) installed monitoring wells with bladders pumps has significantly increased. There are two Geoprobe® bladder pumps (Model A for ½" wells and Model B for ¾" or larger wells) available that permit low-flow sampling in the small-diameter DP installed monitoring wells. The low-flow sampling method is preferred when sampling for volatile contaminants or metal analytes. Both pumps can be used with any of the available flow-through-cells and water quality monitoring probes. Smaller volume flow-through-cells are recommended when available. Use of the bladder pump and flow-through-cell allows you to meet the stringent requirements for monitoring pH, specific conductance, DO, and ORP, and obtaining low-turbidity samples for metals analysis. Groundwater samples may be collected with a tubing bottom check valve (with 3/8-inch OD poly tubing as shown in Fig. 4.12) or a stainless steel mini-bailer assembly when appropriate. While the check valve is the quicker and more economical sampling device, some operators still prefer the traditional mini-bailer. Note: the up and down motion of the check valve may introduce error when collecting samples for volatiles analysis. To avoid volatiles loss, lower the check valve and tubing to the target monitoring zone without the check ball. Drop the check ball to the bottom of the tubing from the ground surface. This seals the check valve and captures the sample inside the tubing without stripping away volatiles. To collect the sample, simply retrieve the tubing from the well riser, remove the check valve, and place the groundwater in an approved container. Before going into the field to sample monitoring wells (or groundwater samplers), be sure to know the level of sample quality that will be required. For high-integrity samples that must meet strict data quality objectives, sampling with a bladder pump may be required. Conversely, if screening level data is required (is it there and about how much?) bladder pumps will be slow and ineffective while the tubing check valve would be sufficient and save time and money. For more information on this topic, request the Geoprobe® bulletin titled *Groundwater Quality and Turbidity vs. Low Flow.*
Equipment Decontamination	Before and after each use, thoroughly clean all parts of the soil sampling system according to project requirements. A clean, new liner is recommended for each use. Parts should also be inspected for wear or damage at this time.

Personnel Decontamination	1. All personnel must go through decontamination procedures whenever leaving a contaminated area. Decontamination procedures should be used in conjunction with methods to prevent contamination including minimizing contact with wastes and maximizing worker protection. Personnel must follow PTS-SOP-DE-01 Personnel Decontamination Procedures.

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This section to be completed with concurrence from the Safety Officer.

SOURCE	*HAZARDS*	*WHERE*	*HOW, WHEN, RESULT*	*CONTROLS*
CHEMICAL	1. Contact with contaminated soils and underground water.	1. Contaminated sites, during sample collection and handling.	1. Adverse health effects could result from ingesting, inhaling, and/or skin/eyes contact with contaminated soils and underground water.	1. Personnel will practice proper personal hygiene – wash hands prior to eating and when leaving the site. Employees will wear nitrile gloves when collecting and handling samples. Work will be suspended during high wind conditions that produce large amounts of visible dust.
	2. Carbon Monoxide (CO).	2. Vehicle and equipment.	2. Potential exposure to CO when working around idling vehicles/ equipment could result in irritated eyes, headache, nausea, weakness and dizziness.	2. Employees will minimize the time sitting in idling vehicles and will open a window to increase ventilation. Employees will avoid working around idling vehicles/equipment and stay up wind.
	3. Hydraulic fluid.	3. Testing sites, when using the Geoprobe.	3. Employees could be exposed to hydraulic fluid via inhalation, ingestion, and skin/eyes contact when checking the hydraulic system of the machine or during spills/leaks resulting in adverse health	3. Employees will prevent skin/eyes contact with hydraulic fluids and they will wear nitrile gloves and eye protection. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available at the site. Cleanup materials will be disposed of according to the appropriate regulations. All components

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			effects.	of the Geoprobe will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
	4. Granular bentonite.	4. Testing sites.	4. Employees could be exposed to granular bentonite via inhalation, ingestion, and skin/eyes contact when sealing well screens resulting in adverse health effects.	4. Personnel will practice proper personal hygiene – wash hands prior to eating and when leaving the site. Employees will wear nitrile gloves and safety glasses when handling granular bentonite. Work will be suspended during high wind conditions that could produce large amounts of visible bentonite dust.
	5. Silica sand.	5. Testing sites.	5. Employees could be exposed to silica sand via inhalation, ingestion, skin/eyes contact when installing a grout/sand barrier for the well resulting in adverse health effects.	5. Personnel will practice proper personal hygiene – wash hands prior to eating and when leaving the site. Employees will wear nitrile gloves and safety glasses when handling silica sand. Work will be suspended during high wind conditions that could produce large amounts of visible silica dust.
	6. Fresh concrete.	6. Testing sites.	6. Employees could be exposed to fresh concrete when installing a concrete pad to support the well cover. Contact with fresh concrete may	6. Employees will wear work boots, gloves, and safety glasses when handling fresh concrete. Workers will also avoid direct contact with fresh concrete and prevent fresh concrete soak into clothing or rub against skin. Proper personal hygiene is

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			result in irritation and/or chemical burns of eyes, skin, and nose. It may also cause dermatitis.	also required when handling fresh concrete.
PRESSURE	1. Pressurized hydraulic lines.	1. Testing sites.	1. Adverse health effects could result from faulty pressurized hydraulic lines.	1. All components of the Geoprobe will be inspected prior to and at the completion of the task.
	2. Pressurized lines from the high-pressure grout pump (Geoprobe® Model GS1000 or GS500).	2. Testing sites.	2. Adverse health effects could result from faulty pressurized lines if using the high-pressure grout pump to inject grout to the bottom of well screens.	2. All components of the high-pressure grout pump will be inspected prior to and at the completion of the task.
	3. Excessive noise levels.	3. Testing sites.	3. Employees could be exposed to excessive noise levels when operating the Geoprobe resulting in irritability, decreased concentration, and noise-induced hearing loss.	3. Personnel operating the Geoprobe will wear double hearing protection (i.e., earplugs and earmuffs). Non-essential personnel will wear hearing protection (e.g., earplugs) and will maintain a 20-foot buffer zone around the Geoprobe when possible.
ELECTRICAL	1. Lightning.	1. Outdoor sites.	1.Electrocution, injury, death, or equipment damage could be caused by	1. Employees will follow the 30/30 rule during lightning storms.

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			lightning strike.	
	2. Contact with overhead utilities.	2. Testing sites.	2. Injury, death or property damage could occur from contact with overhead utilities while operating the Geoprobe.	2. If overhead hazards are present, established overhead utility procedures will be followed. When possible, employees will avoid areas with overhead hazards. Employees will avoid contact with overhead lines when raising the probe unit hammer assembly to its highest position. Employees will not drive the machine with the probe cylinder extended.
	3. Contact with underground utilities.	3. Testing sites.	3. Injury, death or property damage could occur from contact with underground utilities when lowering probe rods into the ground to insert and install monitoring wells.	3. Prior to starting work, employees will call for a utility locate (e.g., call 811 or corresponding phone number). If underground utilities are present, established underground utility procedures will be followed.
MOTION	1. Driving to each site.	1. Road.	1. Incidents could occur when driving resulting in personal injury and/or property damage.	1. Employees will follow defensive driving techniques when operating a vehicle.
	2. Slips and trips.	2. Uneven terrain, slick/muddy/wet surfaces and/or steep slopes.	2. Personal injury such as sprains and muscle/back strains could result from slips	2. Workers will wear work boots with good traction and ankle support. Employees will plan their path and walk cautiously.

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			and trips.	
	3. Bending, squatting and kneeling.	3. Testing sites, when assembling and retrieving probe rods and well components from the subsurface.	3. Bending, squatting and kneeling could result in muscle/back strains or other injuries.	3. Employees should stretch prior to starting work and they will take breaks when necessary.
	4. Improper body mechanics.	4. Testing sites.	4. Back injuries and muscle/back strains could result when using improper techniques to lift and carry probe rods and bags of granular bentonite, silica sand, and other grouting materials. Back injuries and muscle/back strains could also result from using improper techniques when pulling probe rods from the subsurface.	4. Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder height. Two people will lift if necessary. Employees will also use good body mechanics when pulling probe rods from the subsurface: bend knees, lean slightly away from the object, keep back and wrists straight, use legs to move the objects. If necessary, personnel will also use the adjustable rod clamps to facilitate the process of retrieving probe rods from the subsurface.
	5. Struck by and/or caught in between heavy equipment or vehicles.	5. Testing sites.	5. Personnel could be injured if struck by and/or caught in between heavy equipment or vehicles.	5. When applicable, employees will communicate with the contact person of other contractors on site. Personnel will avoid working near other heavy equipment and/or vehicles, when possible. High visibility

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				clothing will be worn.
	6. Contact with moving components of the Geoprobe.	6. Testing sites, when operating the machine.	6. Adverse health effects could result from touching moving components when operating the Geoprobe.	6. Employees will not touch moving components of the machine. Personnel will tie back long hair and will not wear loose clothing and jewelry. Work gloves are required when operating the machine. All personnel will be clear of all moving parts before starting the engine. Operators will stand to the control side of the machine, clear of the probe foot and derrick, while operating the controls. Personnel will never reach across the probe assembly to manipulate the machine controls.
	7. Pinch points.	7. During equipment assembly.	7. Employees could be exposed to hand injuries such as lacerations, punctures, cuts and pinched fingers when assembling the probe rods and well components.	7. Employees will always wear work gloves when operating the Geoprobe and handling its components.
	8. Flying debris/grout material.	8. During equipment assembly and installation of monitoring wells.	8. Eye injuries could result from flying debris/grout material.	8. Employees will wear safety glasses at all times.

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		Also, when using the high-pressure grout pump (Geoprobe® Model GS1000 or GS500).		
GRAVITY	1. Falls from slips and trips.	1. Uneven terrain, slick/muddy/ wet surfaces and steep slopes.	1. Workers could be injured if they fall causing bruises, scrapes, or broken bones.	1. Workers will wear work boots with good traction and ankle support. Employees will plan their path and walk cautiously.
	2. Falling equipment and/or tools.	2. Testing sites.	2. Personnel could be injured if exposed to falling equipment and/or tools (e.g., probe rods) when operating the Geoprobe.	2. Employees will wear steel-toed boots and hard hat when operating the Geoprobe. Personnel will practice good housekeeping at all times and keep the work area organized.
THERMAL	1. Cold/heat stress.	1. Sites.	1. Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	1. Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day.
	2.Hypothermia/ frostbite.	2. Sites where air temperature is 35.6°F (2°C) or less.	2. Workers whose clothing becomes wet may be exposed to hypothermia and/or frostbite.	2. Employees will change clothing if it becomes wet.

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RADIATION	1. Ultraviolet (UV) radiation.	1. Outdoors.	1. Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	1. Employees should wear sunscreen. Employees will wear long-sleeve work shirts and long pants. Employees should also use safety glasses with tinted lenses.
BIOLOGICAL	1. Untrained worker. 2. Plants, insects, and animals.	1. Sites. 2. Sites.	1. Adverse health effects or injury could result from lack of training. 2. Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, swelling and other personal injuries.	1. Employees will be properly trained in this procedure and other applicable procedures. All employees operating the machine will be familiar with the basic controls of the machine including the Emergency Kill switch button. 2. Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety Officer.	
REQUIRED PPE	Level D: hard hat, safety glasses, high-visibility work shirt or vest, long pants, steel-toed boots, and work gloves.
APPLICABLE MSDS	MSDSs will be maintained based on site characterization and contaminants. Hydraulic Fluids. Carbon Monoxide. Granular Bentonite. Silica Sand.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety Officer.	
	Cement.
REQUIRED PERMITS/FORMS	Daily Toolbox Meeting Record and TSEA, where applicable.
ADDITIONAL TRAINING	OSHA 40-hour HAZWOPER/8-hour Refresher.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	Map with site location and sample locations.
ROUTINE TASKS	Bending, squatting, kneeling, lifting, pulling, visual verification of performance, and data recording.
RELATED SOPs/PROCEDURES/ WORK PLANS	Related SOPs: PTS-SOP-DE-01 Personnel Decontamination Procedures.
TOOLS	The following equipment is required to install a permanent monitoring well with the Geoprobe® 1.4-inch OD prepacked screens and direct push system. Refer to Figures 3.1 and 3.2 for illustrations of well components.

0.5-IN. X 1.4-IN. OD PREPACK WELL COMPONENTS	Quantity	Part Number
0.5-in. x 1.4-in. OD Prepacked Screen, 3-ft. length	variable	GW2010
0.5-in. x 1.4-in. OD Prepacked Screen, 5-ft. length	variable	GW2020
Snap-Lock Connector Assembly, 0.5-in. sch. 80	-1-	GW2030
Expandable Anchor Point, 2.5-in. OD	-1-	GW2040
PVC Riser, 0.5-in. sch. 80, 5-ft. length	variable	GW2050
O-rings for 0.5-in. PVC Riser, Pkg. of 25	variable	GW430R
PVC Top Cap, 0.5-in. sch. 80 Flush Thread	-1-	GW2055
Locking Well Plug, for 0.5-in. sch. 80 riser	-1-	WP1750
Vinyl Cap, 0.812-in. ID (optional)	-1-	AT441
PVC Bottom Plug, 0.5-in. sch. 80 Flush Thread (optional)	-1-	GW2056
Expandable Drive Point, 2.125-in. rods / 2.5-in.	-1-	AT2015

OD (optional)		

0.75-IN. X 1.4-IN. OD PREPACK WELL COMPONENTS	Quantity	Part Number
0.75-in. x 1.4-in. OD Prepacked Screen, 3-ft. length	variable	11678
0.75-in. x 1.4-in. OD Prepacked Screen, 5-ft. length	variable	17466
Snap-Lock Connector Assembly, 0.75-inch sch. 40	-1-	17469
Expendable Anchor Point, 2.5-in. OD	-1-	GW2040
PVC Riser, 0.75-in. sch. 40, 5-ft. length	variable	11747
O-rings for 0.75-in. PVC Riser, pkg. of 25	variable	GW4401R
Vinyl Cap, 1.0-in. ID	-1-	12258
Locking Well Plug, for 0.75-in. sch. 40 riser	-1-	WP1775
PVC Bottom Plug, 0.75-in. sch. 40 Flush Thread (optional)	-1-	12385
Expendable Drive Point, 2.125-in. rods / 2.5-in. OD (optional)	-1-	AT2015

MONITORING WELL ACCESSORIES	Quantity	Part Number
Well Cover, flush-mount, 4-in. x 12-in., cast iron / ABS skirt (optional)	-1-	WP1741
Well Cover, flush-mount, 7-in. x 10-in., cast iron / galvanized skirt (optional)	-1-	WP1771
Sand, environmental grade (20/40 mesh)	variable	AT95
Bentonite, granular (8 mesh)	variable	AT91
Bentonite, powdered (200 mesh)	variable	AT92
Portland Cement, Type I	variable	
Concrete Mix (premixed cement and aggregate)	variable	
Clean Water (of suitable quality for exposure to well components)	variable	

GEOPROBE® TOOLS AND EQUIPMENT	Quantity	Part Number
O-rings for 2.125-in. Probe Rod, pkg. of 25	variable	AT2100R
Drive Cap, 2.125-in.	-1-	AT2101
Expendable Point Holder, 2.125 x 36, 48 or 60 in.	-1-	AT2110, AT2111, or AT2112
Probe Rod, 2.125-in. x 36, 48, or 60 in.	variable	AT2136, AT2148, or AT2160
Probe Rod, 2.125-in. x 1 meter (optional)	variable	AT2139
Rod Grip Puller Assembly (GH40) or Rod Grip Handle (GH60)	-1-	GH2150K or 9640
Extension Rod, 36-, 48-, or 60-in.	variable	AT67, AT671, or 10073
Extension Rod, 1 meter (optional)	variable	AT675
Extension Rod Coupler	variable	AT68
Extension Rod Handle	-1-	AT69
Extension Cord Quick Links (optional)	variable	AT694K
Grout Machine	-1-	GS1000 or GS500
Grout System Accessories	-1-	GS1010 or GS1012
Water Level Sounder	-1-	GW1200
Screen Push Adapter	-1-	GW1535
Stainless Steel Mini-Bailer Assembly (optional)	-1-	GW41
Pneumatic Bladder Pump (optional)	-1-	GW1400 Series
Tubing Bottom Check Valve	-1-	GW42
Polyethylene Tubing, 3/8-in. OD (for sampling, etc.)	variable	TB25L
Nylon Tubing, 3/8-in. OD (for grouting)	variable	11633

Additional Tools and Equipment	Quantity
Locking Pliers	-2-
Pipe Wrench	-2-
Volumetric Measuring Cup	-1-
PVC Cutting Pliers	-1-
Weighted Measuring Tape (optional)	-1-
Small Funnel or Flexible Container (for pouring sand)	-1-

Duct or Electrical Tape Roll	-1-
Bucket or Tub (for dry grout material, water, and mixing)	-3-

FORMS/CHECKLIST

APPROVALS/CONCURRENCE

By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.

PROJECT MANAGER	**DATE**
SAFETY OFFICER	**DATE**
CREW LEAD or SAMPLER LEAD	**DATE**
SAMPLER	**DATE**

APPROVALS/CONCURRENCE

By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.

OTHER	**DATE**
OTHER	**DATE**

Revisions:

Rev.	Description	Date	Approval

Geoprobe Prepacked Screen Monitoring Well - Figures

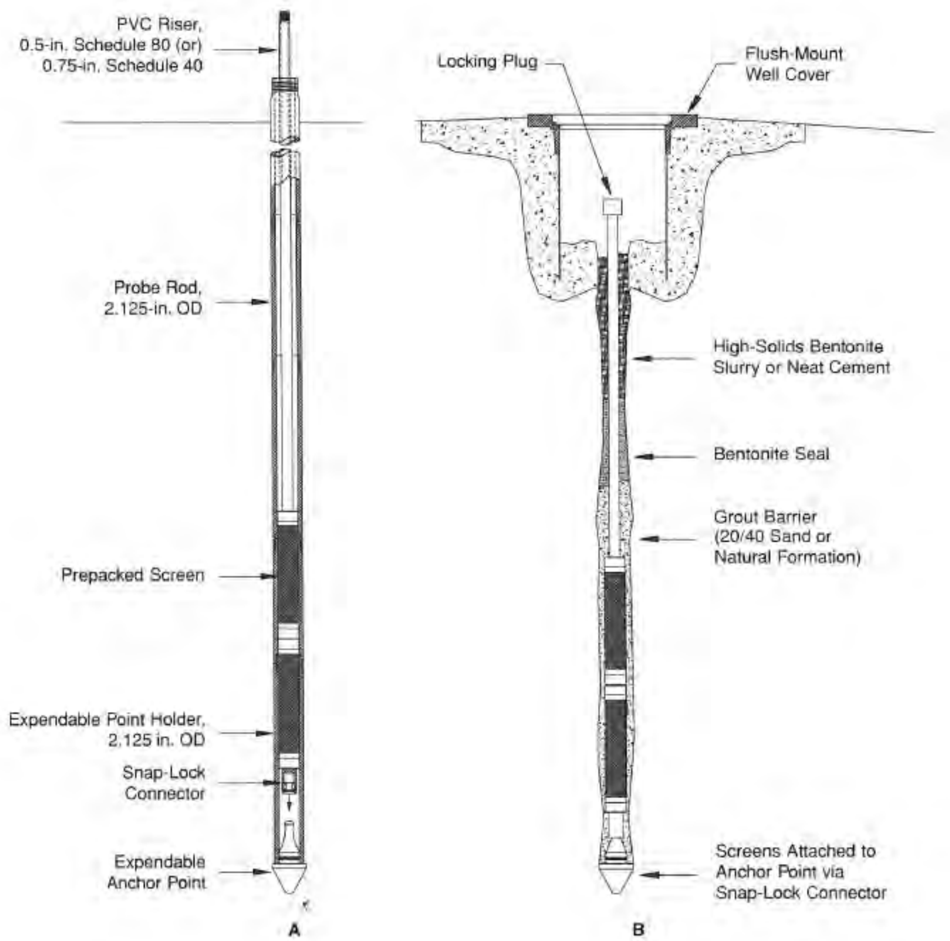

Figure 2.1:
Insertion of Prepacked Screens (A) and Installed Geoprobe Monitoring Well (B

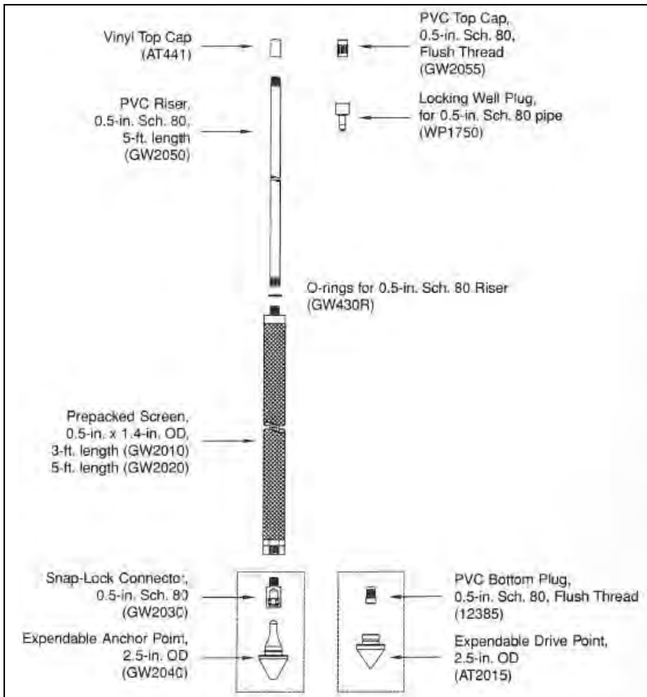

Figure 3.1:
0.7-in. x 1.4-in. OD Prepacked Screen Monitoring Well Parts

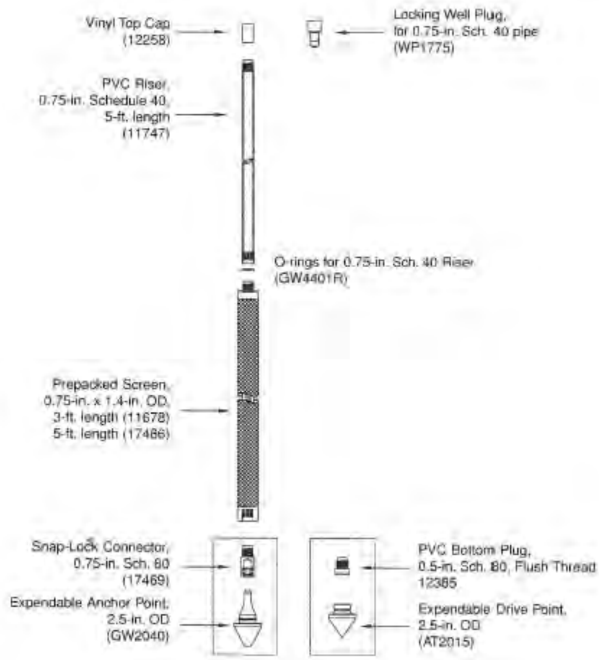

Figure 3.2:
0.75-in. x 1.4-in. OD Prepacked Screen Monitoring Well Parts

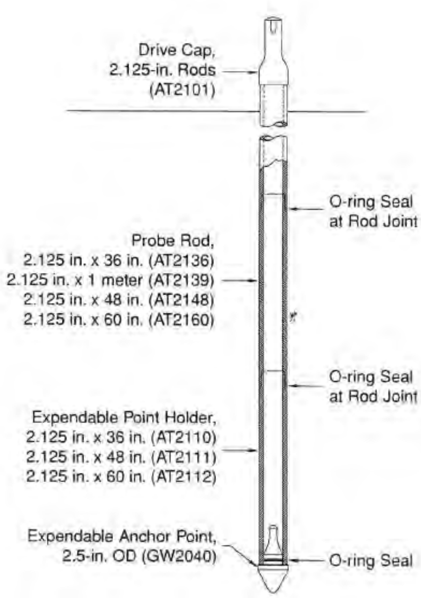

Figure 4.1:
Expendable Anchor Point Driven to Depth

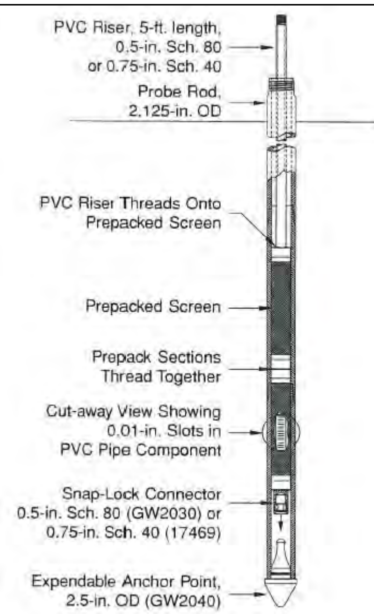

Figure 4.2:
Prepacked Screens Inside Probe Rod String

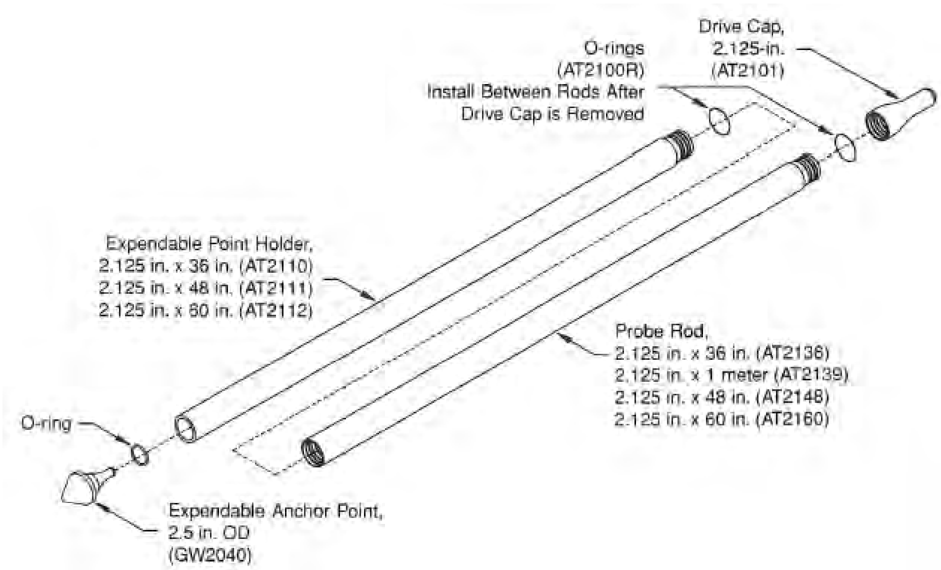

Figure 4.3:
2.125-inch OD Probe Rod Assembly

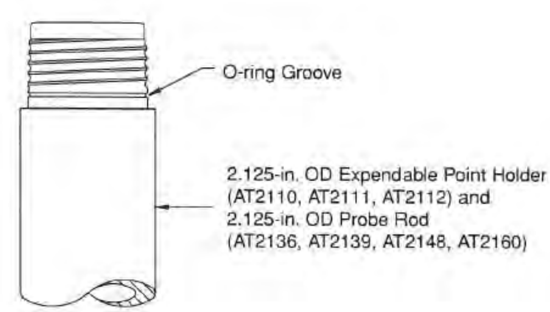

Figure 4.4:
O-ring Groove in 2.125-inch Expendable Point Holders and Probe Rods

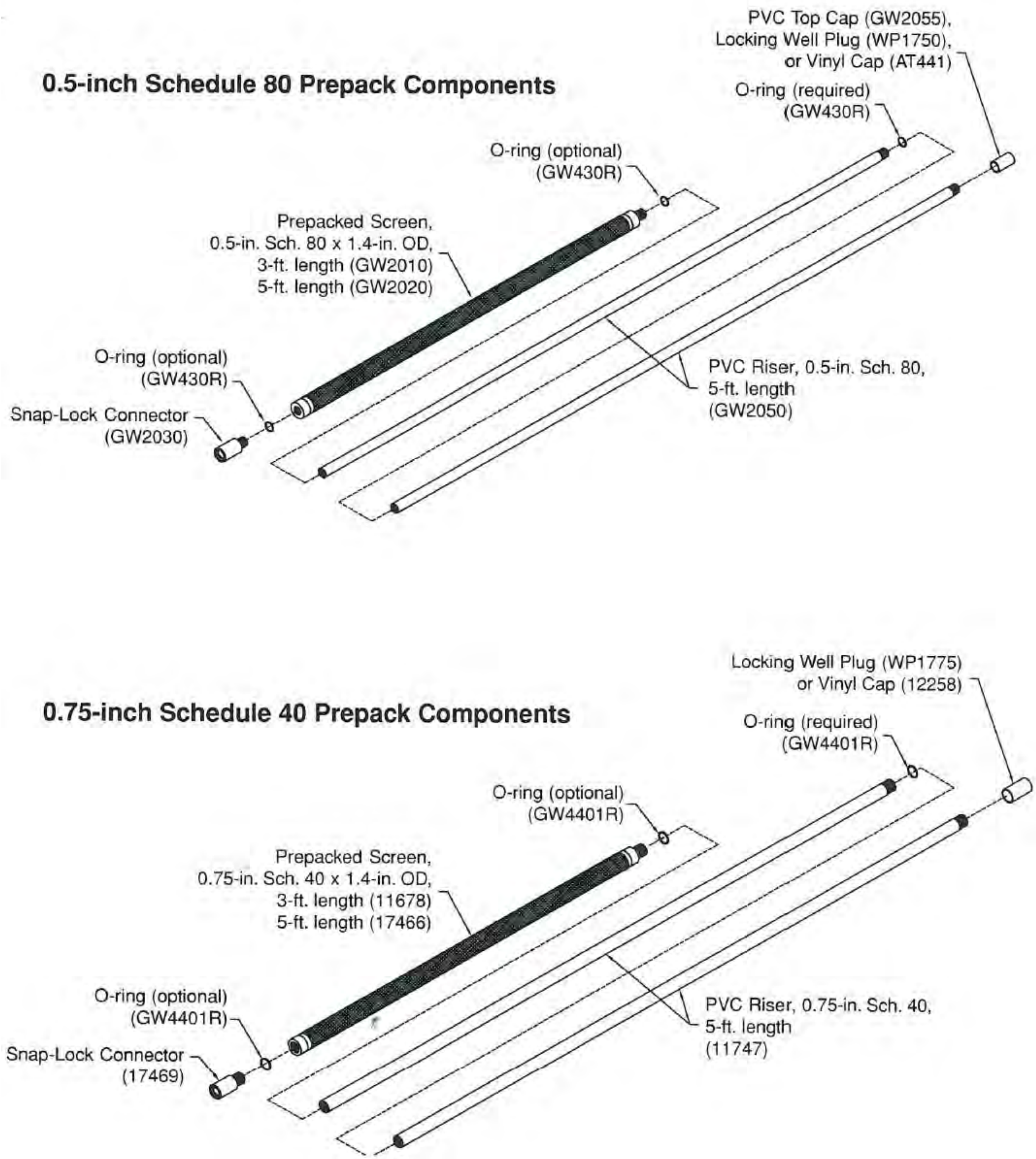

Figure 4.5:
0.5-inch Schedule 80 and 0.75-inch Schedule 40 Prepacked Screen Components

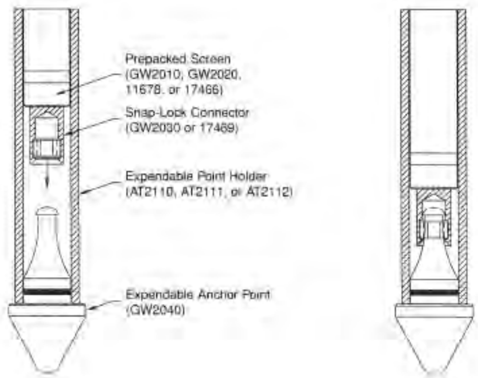

Figure 4.6:
Connecting Prepack(s) to Expendable Anchor Point

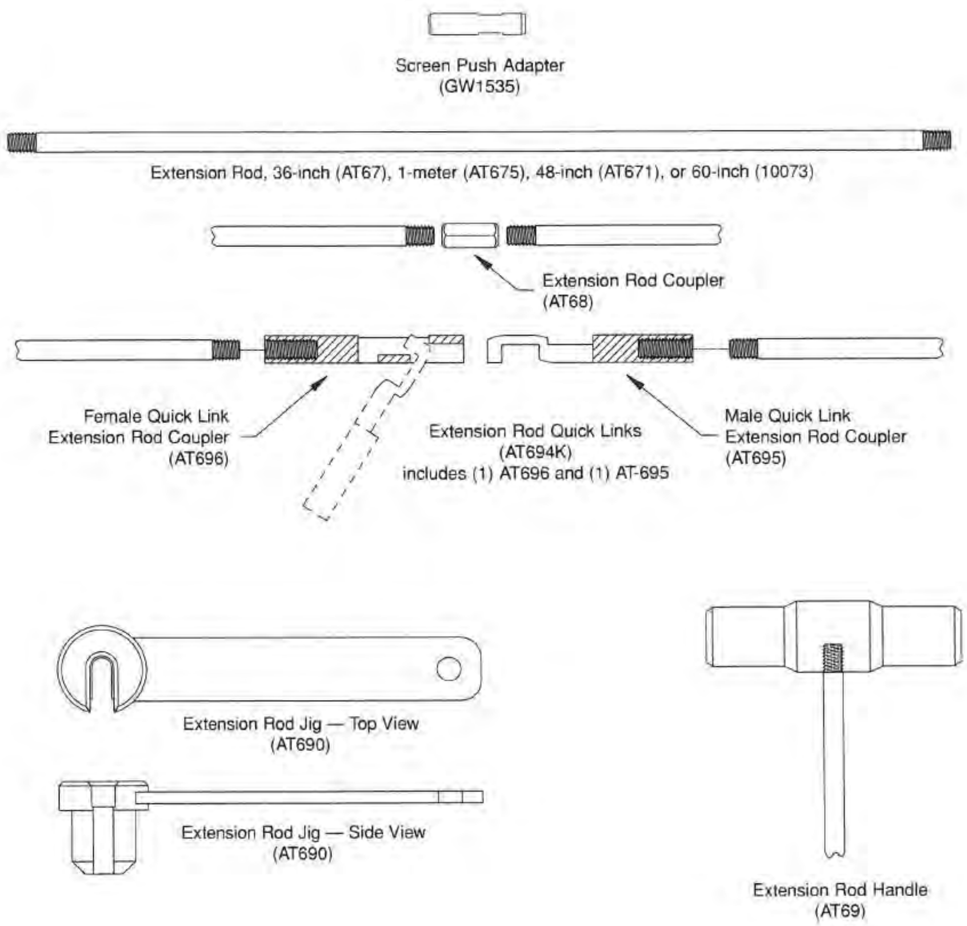

Figure 4.7:
Geoprobe Extension Rods and Accessories

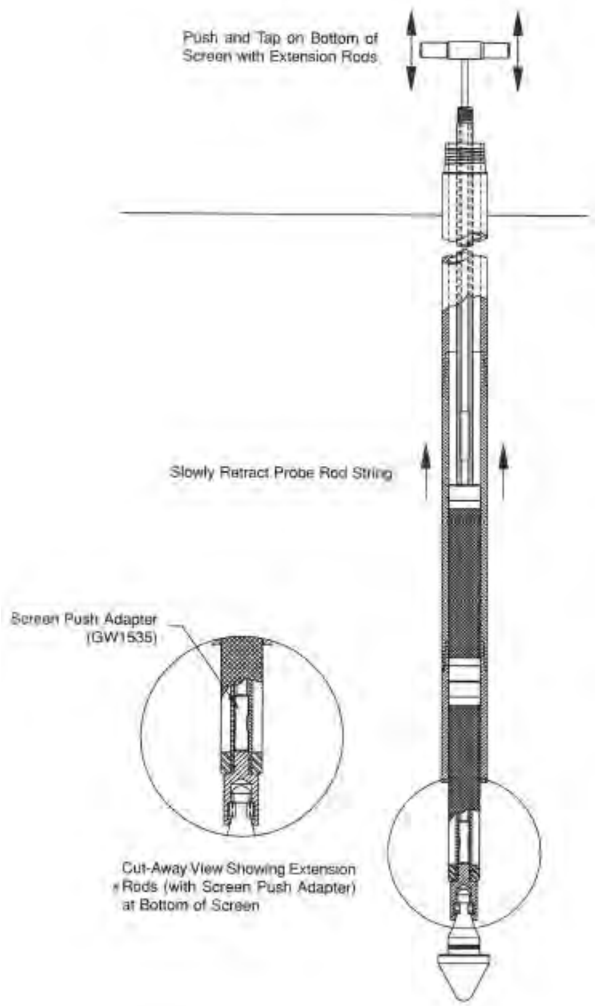

Figure 4.8:
Use Extension Rods to Tap Out Wedged Screens

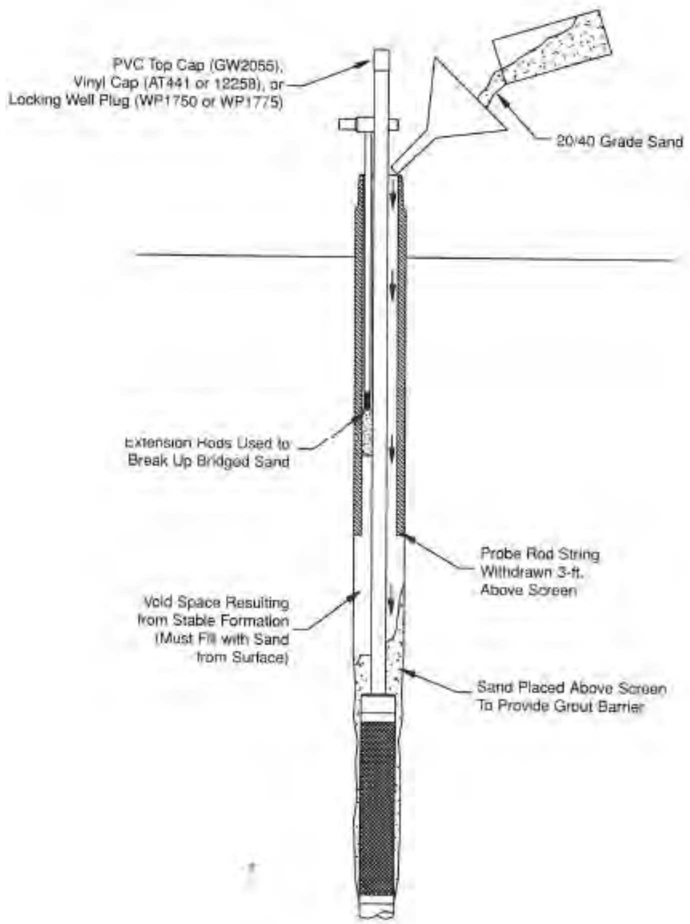

Figure 4.9:
Installing Grout Barrier from Ground Surface with 20/40 Mesh Sand

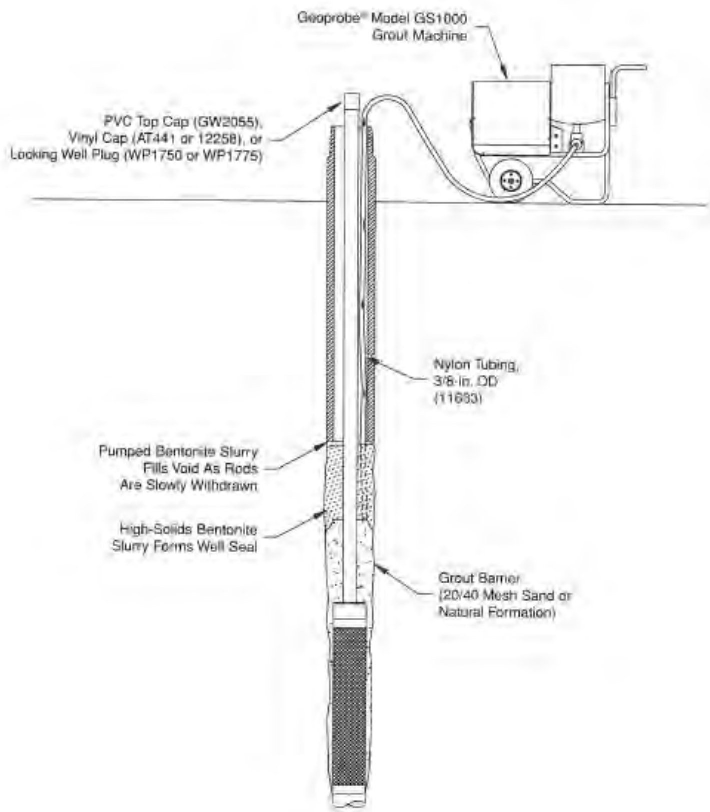

Figure 4.10:
Providing Bentonite Seal With Geoprobe® Model GS1000 Grout Machine

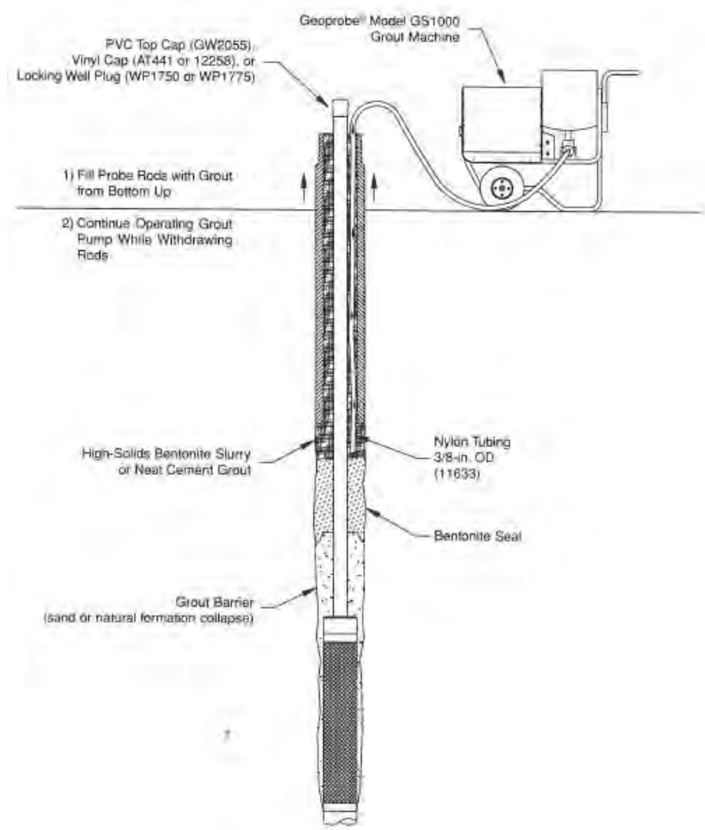

Figure 4.11:
Grouting Well Annulus with Geoprobe® Model GS1000 Grout Machine

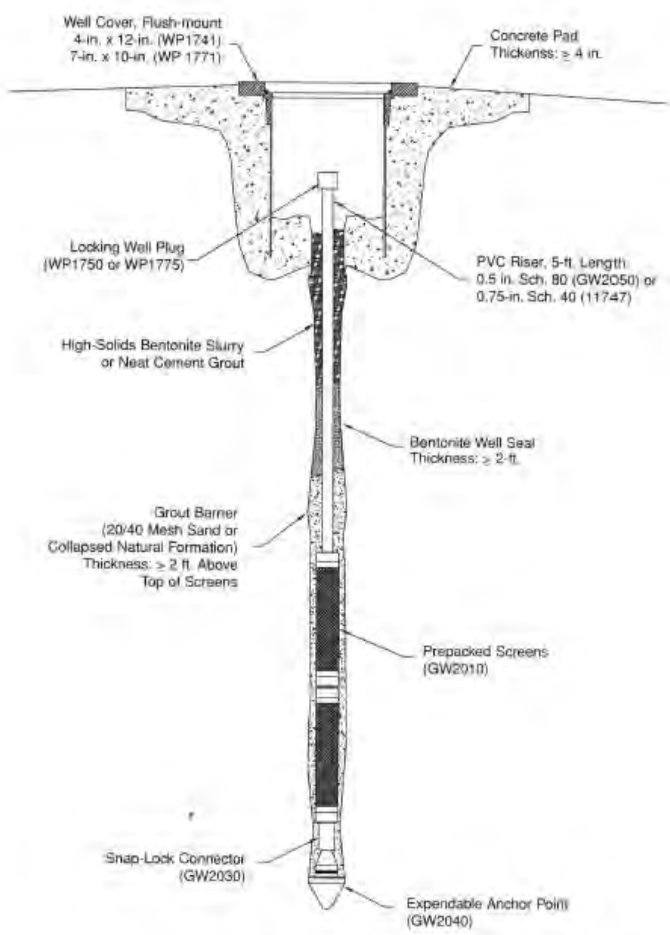

Figure 4.12:
A Properly Installed Geoprobe® Prepacked Screen Monitoring Well

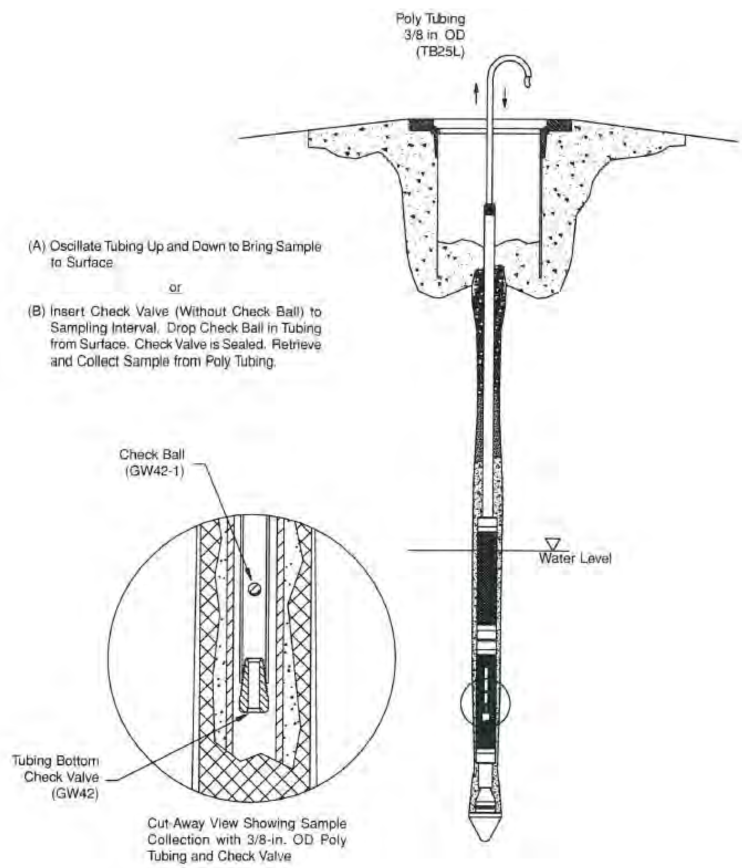

Figure 4.13:
Sampling with Polyethylene Tubing and a Tubing Bottom Check Valve

PURPOSE	To provide standard instructions for using a DH66 Automatic Drop Hammer to perform Standard Penetration Test (SPT).
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Mounting the DH66 Automatic Drop Hammer on the Geoprobe® Machine	This section describes how to mount the DH66 Automatic Drop Hammer on a Geoprobe® track machine: 1. Attach a hitch-mounted basket to the back of the Geoprobe®. 2. Place four counterweights (75 pounds each) inside the hitch-mounted basket. 3. Using a hand dolly, place the drop hammer next to the Geoprobe®. 4. Attach the overhead winch of the rig to the drop hammer. 5. Using the winch device, lift the drop hammer into position. 6. Attach the drop hammer to the Geoprobe® (top and bottom supports). 7. Secure the drop hammer to the Geoprobe® by inserting the safety pin (L-shaped bar) in the bottom support. 8. Connect hydraulic lines to the drop hammer. 9. Detach the overhead winch from the drop hammer.
Assembling and Driving the Outer and Inner Rods	An outer casing is first driven through the undisturbed soil with the probe unit hammer assembly to reach the top of the testing intervals. Specific instructions are listed below. 1. Align the probe unit hammer assembly with the identified/applicable location. 2. Thread a cutting shoe to the leading end of a heavy-weight outer rod (3.25-

	in. ODx60-in. length). 3. Thread a solid drive tip to the leading end of a heavy-weight inner rod (1.25-in ODx60-in length). 4. Insert the heavy-weight inner rod into the outer rod until the solid drive tip partially extends from the bottom of the cutting shoe. 5. Thread a drive cap to the top of the heavy-weight inner rod. 6. Place a threadless drive cap on top of the heavy-weight outer rod. 7. Raise the probe unit hammer assembly to its highest position by fully extending the probe cylinder. 8. Position the assembled rods directly under the probe unit hammer assembly with the cutting shoe centered between the toes of the probe foot. The heavy-weight outer rod should now be parallel to the probe derrick. A magnetic level should be placed on the heavy-weight rod to check level. 9. Start the probe unit hammer assembly to advance the assembled rods into the ground until reaching the desired testing depth below ground surface.
Using the DH66 Automatic Drop Hammer	After the assembled rods have been driven into the ground to reach the top of the desired testing intervals, the operator can start using the DH66 Automatic Drop Hammer (drop hammer). Step by step instructions are listed below. 1. Raise the probe unit hammer assembly a few feet and retract the Geoprobe® to provide access to the top of the rods. 2. Remove the threadless drive cap on top of the heavy-weight outer rod. 3. Pull up the heavy-weight inner rod and remove the solid drive tip. 4. Using a marker, mark the desired testing intervals on the heavy-weight inner rod. 5. Thread a cutting shoe onto the leading end of a split spoon and an adapter pin onto the opposite end of the split spoon. Connect the heavy-weight inner rod to the split spoon using the adapter pin. 6. Insert the heavy-weight inner rod and the split spoon into the outer rod that was previous driven into the ground. 7. Move the Geoprobe® to position the drop hammer directly above the heavy-weight inner rod. 8. Turn the drop hammer on to advance the heavy-weight inner rod and split spoon into the ground until reaching the desired testing depth. The operator

will count the number of blow counts that is takes to reach each testing interval previously marked on the heavy-weight inner rod.

9. Reposition the Geoprobe® so the probe unit hammer assembly is directly above the heavy-weight inner rod. Using the probe machine and a pull cap, pull up the heavy-weight inner rod and split spoon. The outer rod remains in the ground.

10. Remove the split spoon from the heavy-weight inner rod. Also, remove the cutting shoe and adapter pin from the split spoon. Open the split spoon and collect the soil sample. Then, thread the cutting shoe back onto the leading end of the split spoon and the adapter pin onto the opposite end.

11. Thread a solid drive tip onto the leading end of a heavy-weight inner rod and connect an additional heavy-weight inner rod to other end of the rod. Using a marker, mark the desired testing intervals on the newly added heavy-weight inner rod.

12. Thread a drive cap onto the top of the heavy-weight inner rod tool string.

13. Insert the assembled heavy-weight inner rod tool string into the heavy-weight outer rod that was previously driven into the ground.

14. Using the overhead winch, raise a heavy-weight outer rod and place it through the tool string of heavy-weight inner rods. Thread the heavy-weight outer rod onto the outer rod that was previously driven into the ground.

15. Place a threadless drive cap on top of the heavy-weight outer rod tool string.

16. Using the probe unit hammer assembly, drive the assembled rods into the ground.

17. Remove the threadless drive cap from the heavy-weight outer rods and the threaded drive cap from the heavy-weight inner rods.

18. Thread a loop pull cap onto the tool string of heavy-weight inner rods.

19. Connect the overhead winch to the loop pull cap and remove the heavy-weight inner rod tool string.

20. Remove the solid drive tip from the heavy-weight inner rods and thread a split spoon onto the assembled heavy-weight inner rods.

21. Replace the loop pull cap on the heavy-weight inner rods with a threaded drive cap.

22. Insert the assembled heavy-weight inner rod tool string into the heavy-weight outer rod that was previously driven into the ground.

	23. Reposition the Geoprobe® so the drop hammer is directly above the heavy-weight inner rods. 24. Turn the drop hammer on to drive the tool string of heavy-weight inner rods and split spoon into the ground until reaching the desired testing depth. The operator will count the number of blow counts that is takes to reach each testing interval previously marked on the heavy-weight inner rod. Repeat steps 9 to 24 until reaching the end of the testing depth. ***Note:*** *as the assembled rods get longer and heavier, use the probe machine, the overhead winch, and/or the adjustable rod clamp to facilitate the process of placing and retrieving rods.*
Outer Casing Retrieval	The outer casing may be retrieved in one of three ways: 1. Casing pulled then probe hole sealed from ground surface with granular bentonite. The outer casing may be pulled from the ground with the probe machine and a pull cap, if the probe hole is to be sealed with granular bentonite from the ground surface. This method is used for shallow probe holes in stable formations only. Such conditions allow the entire probe hole to be sealed with granular bentonite. 2. Casing pulled with probe hole sealed from bottom-up during retrieval. Bottom-up grouting should be performed during casing retrieval in unstable formations where side slough is probable. Such conditions create void spaces in the probe hole if granular bentonite is installed from the ground surface. 3. Casing pulled with Geoprobe® Prepacked Screen Well installed during retrieval. The final option is to install a 2.5-inch OD Geoprobe® Prepacked Screen Monitoring Well in the probe hole during retrieval of the outer casing. When sampling is complete, the outer rods are raised a few inches, and an expendable cutting shoe is deployed from the holder. This leaves an open casing through which a set of prepacked screens is lowered on the leading end of a PVC riser string. The well is finished, complete with grout barrier, bentonite well seal, and a high-solids bentonite slurry/neat cement grout, during retrieval of the outer casing.

HSSE CONSIDERATIONS

This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	*HAZARDS*	*WHERE*	*HOW, WHEN, RESULT*	*CONTROLS*
CHEMICAL	Contact with impacted soils and water.	Impacted sites, during sample collection and handling.	Adverse health effects could result from ingesting, inhaling, and/or skin/eye contact with impacted soils and water.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves when collecting and handling samples. Employees will wear work gloves when handling probe rods. Work will be suspended during high wind conditions that produce large amounts of visible impacted dust.
	Hydraulic fluid and diesel.	Geoprobe®.	Employees could be exposed to hydraulic fluid and/or diesel via inhalation, ingestion, and skin/eye contact, when operating the Geoprobe®, or if equipment malfunctions resulting in adverse health effects.	Employees will wear work gloves and eye protection, if contact with hydraulic fluid/diesel is possible. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe® trailer. Cleanup materials will be disposed of according to the appropriate regulations. All components of the rig will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
	Lubricating grease.	Probing location.	Employees could be exposed to lubricating grease via ingestion and skin/eye contact when assembling probe rods resulting in adverse health effects.	Employees will wear work gloves and eye protection when assembling probe rods.

PRESSURE	Pressurized hydraulic lines.	Geoprobe®.	Faulty pressurized hydraulic lines could burst resulting in personal injury/exposure and hydraulic fluid release.	All components of the rig will be inspected prior to and at the completion of the task.
	Excessive noise levels.	Drop hammer.	Employees could be exposed to excessive noise levels when the drop hammer is in motion resulting in irritability, decreased concentration, and noise-induced hearing loss.	The operator and helper will wear double hearing protection (i.e., earplugs and earmuffs). Non-essential personnel will wear single hearing protection and maintain a 20-foot buffer zone around the rig.
ELECTRICAL	Defective electrical lines.	Geoprobe®.	Contact with defective electrical lines could result in personal injury.	Inspect electrical lines of the Geoprobe® prior to and at the completion of the task.
	Lightning.	All sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
	Contact with overhead utilities.	Probing location.	Injury, death, or property damage could occur from contact with overhead utilities when the hammer assembly is raised to its highest position.	If overhead hazards are present, established overhead utility procedures will be followed. Probe locations will be moved to avoid working around overhead utilities. Employees will maintain the required minimal radial clearance distances based on voltage when working around overhead lines.

	Contact with underground utilities.	Probing location.	Injury, death or property damage could occur from contact with underground utilities when geoprobing.	Prior to starting work, employees will call for a utility locate (i.e., call 811). If underground utilities are present, established underground utility procedures will be followed. Probe locations will be moved to avoid working around underground utilities.
MOTION	Geoprobe® shifting.	Probing location, when using the drop hammer and working on a sloped surface.	Personal injury and equipment damage could occur if the Geoprobe® shifts while using the drop hammer and when working on a sloped surface.	When using the drop hammer, do not raise the machine foot more than approximately 6 inches off the ground or the vehicle may become unstable and shift. When working on a sloped surface, position the rig so that it is facing upslope. In the event that the probe unit loses stability, it will roll away from the operator without causing injury.
	Struck by the Geoprobe®/drop hammer.	Operating the Geoprobe®/ drop hammer.	Personnel could be injured if struck by the Geoprobe®/drop hammer.	Non-essential personnel will maintain a 20-foot buffer zone around the rig.
	Improper body mechanics.	Assembling, handling, and retrieving rods/sample tubes.	Improper lifting, bending, squatting, and kneeling could result in muscle/back strains or other injuries.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder height. Two people will lift, if necessary. Employees will also use good body mechanics when retrieving rods/sample tubes: bend knees, lean slightly away from the object, keep back and wrists straight, use legs to move the objects.

				Employees should stretch prior to starting work and they will take breaks when necessary.
	Back injuries.	Moving the drop hammer with hand dolly.	Back injuries and muscle/back strains could result when using the hand dolly to move the drop hammer.	Employees will inspect the hand dolly (including all wheels) before using it. Two employees will load the drop hammer on the hand dolly. Workers will use proper body mechanics when loading the drop hammer. Employees will make sure the weight is evenly distributed on all wheels of the hand dolly. Employees will always push a hand dolly to move the load, instead of pulling the hand dolly. Personnel will use a belt to keep the drop hammer from shifting or slipping.
	Contact with rotating and moving parts of the drop hammer.	When the drop hammer is in motion.	Fingers/hands could become pinched or caught in moving/rotating parts of the drop hammer resulting in cuts, scrapes, and/or broken bones.	Employees will not touch moving/rotating parts of the drop hammer. Work gloves are required when operating the drop hammer. Operators will stand to the control side of the machine, clear of the probe foot and drop hammer, while operating the controls. Personnel will never reach across the probe assembly to manipulate the machine controls. All employees on site will be familiar with the basic controls of the machine including the Emergency Kill switch button.

	Pinch points.	When mounting the drop hammer, while the drop hammer is in motion, assembling probe rods, and extracting probe rods.	Employees could be exposed to hand injuries such as lacerations, punctures, cuts, and pinched fingers.	Employees will always wear work gloves. Employees will never place their hands on top of the tool string while raising or lowering the drop hammer.
	Flying debris.	Probing location.	Eye injuries could result from flying debris when driving tool strings into the ground with the drop hammer.	Employees will wear safety glasses at all times during Geoprobe® operations.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Employees will plan their path and walk cautiously. Keep work area free of tools/rods. If conditions are wet/muddy, muck boots may be worn. Site can be cleared of snow, if applicable.
	Falling rods and drop hammer.	Probing location.	Personnel could be injured if exposed to falling rods when assembling/ handling tool strings, and exposed to the drop hammer when handling and attaching it to the Geoprobe®.	Level D PPE is required at all times. Employees will use work gloves when assembling/handling rods. Two workers will carry rods, if necessary.
THERMAL	Cold/heat stress.	Outdoors.	Exposure to cold climates may result in cold	Training on signs and symptoms of cold/heat stress. Personnel will wear

			burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear sunscreen, long-sleeve work shirts and long pants. Employees will also use safety glasses with tinted lenses.
BIOLOGICAL	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. All employees operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency Kill switch button.
	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies should notify their supervisor.

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Level D PPE, earplugs, and earmuffs.
APPLICABLE MSDS	MSDSs will be maintained based on site characterization and contaminants. Hydraulic fluid, diesel, lubricating grease.

REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	
TOOLS	DH66 automatic drop hammer: hitch mounted basket, counterweights, hand dolly, pipe wrench, safety pin, machine vise, work table, and deionized water.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
SAFETY AND HEALTH MANAGER	**DATE**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for equipment decontamination (inorganic contaminants – heavy metals).
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.
NOTES	All equipment leaving the contaminated area of a site must be decontaminated. Decontamination methods include removal of contaminants through physical, chemical, or a combination of both methods. Decontamination procedures are to be performed in the same level of protection used in the contaminated area of a site. In some cases, decontamination personnel may be sufficiently protected by wearing one level lower protection. The information for site specific equipment decontamination and personnel protection levels, as detailed in the Sampling and Analysis Plan (SAP) or work plan, should be followed. The following decontamination procedures are for typical uncontrolled hazardous waste sites. For a specific or unusual contaminant, such as dioxins, see the Site Specific Health and Safety Plan (SSHASP) and consult with the Safety and Health Manager. Decontamination procedures should be used in conjunction with methods to prevent contamination of sampling and monitoring equipment. If practical, one-time-use equipment should be used, and disposed of in accordance with the SAP, work plan, and SSHASP.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
1. Remove gross contamination.	Remove gross contamination with a tap water rinse. If available, use pressurized or gravity flow tap water. If not, a 5-gallon bucket of tap water and a stiff brush may be used.
2. Wash equipment.	Wash equipment in a solution of soap (no phosphate) and tap water with a stiff brush.
3. Triple rinse equipment.	Triple rinse the equipment with tap water. Then, rinse the equipment with de-ionized or distilled water.
4. Rinse equipment with nitric acid/distilled	If specified in the SAP, work plan, or SSHASP, rinse the equipment with a mixture of 10:1 nitric acid in distilled water (10 parts water to 1 part nitric acid). In many cases, the tap water and de-ionized water rinses will be sufficient. If a nitric rinse is used, rinse the equipment again with distilled water.

water mixture.	
5. Air dry equipment.	Place equipment on plastic sheeting or foil to air dry.
6. Transport/ store equipment.	Wrap equipment in foil or plastic wrap to transport or store.
7. Triple rinse decontamination equipment.	Triple rinse equipment (i.e., brushes, buckets, tubs, etc.) used in the decontamination process with water, preferably pressurized.
8. Wash decontamination equipment.	Agitate the equipment used in the decontamination process in the soap/tap water solution. (The tub which holds the solution will only have the water rinse)
9. Triple rinse decontamination equipment.	Triple rinse equipment with tap water.
10. Store and label decontamination equipment.	Place equipment in appropriate areas, so they are used only for decontamination purposes. Label the equipment, if necessary.
11. Dispose of decontamination solutions.	Use a waste water container to properly dispose of the soap/tap water solution, the tap water rinse, and the de-ionized water rinse. Use an organic solvent waste container to properly dispose of the solvent rinse. When contaminants have been identified, either in the solutions or elsewhere on the site, solutions should be disposed of appropriately as discussed in the SAP, work plan, or SSHASP. If they are hazardous (e.g., characteristic, listed, etc.), dispose of them as such. Note: when using other than the above mentioned solutions, check with the Safety and Health Manager and the Project Manager. Some solvents must be evaporated.
12. Measure effectiveness of procedures.	Effectiveness of the decontamination procedures will be measured using field equipment rinsate blanks (see the Site-Specific Quality Assurance Project Plan).

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated items and resulting water from decontamination procedures.	Sites.	Inadvertent exposure to contaminated items and water resulting from decontamination procedures could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will follow decontamination procedures as described above. Employees will wear nitrile gloves when handling contaminated items.
	Nitric acid.	Sites.	Employees could be exposed to nitric acid via ingestion and skin/eye contact when decontaminating equipment. Exposure could cause irritation of skin/eye and dental erosion.	Employees will prevent skin/eye contact with nitric acid and they will wear nitrile gloves and eye protection when handling nitric acid and the nitric acid and distilled water mixture.
PRESSURE				
ELECTRICAL	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
MOTION	Improper lifting.	Sites.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry 5-gallon containers of tap water.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder height.
	Struck by and/or caught in between	Sites.	Personnel could be injured if	When applicable, employees will communicate with the

HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

	heavy equipment or vehicles.		struck by and/or caught in between heavy equipment or vehicles while performing decontamination procedures.	contact person of other contractors on the site. Personnel will avoid working near heavy equipment/vehicles, when possible. High visibility clothing will be worn. When possible, personnel will park field vehicles or use traffic cones to prevent third party vehicles from coming into the work area.
GRAVITY	Slips and falls.	Areas designated for decontamination procedures.	Slips and falls could occur while performing decontamination procedures due to slippery surfaces resulting in bruises, scrapes, or broken bones.	Workers will wear work boots with good traction and ankle support. Keep work areas as dry as possible. Wear muck boots, as necessary.
THERMAL	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day.
	Hypothermia/frost bite.	Sites where air temperature is 35.6°F (2°C) or less.	Workers whose clothing becomes wet during decontamination procedures may be exposed to hypothermia and/or frostbite.	Employees will change clothing, if it becomes wet.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV	Employees will wear sunscreen, long-sleeve work

HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

			radiation during summer months causing sun burns, skin damage, and eye damage.	shirts and long pants. Employees will also use safety glasses with tinted lenses.
BIOLOGICAL	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures.
	Plants, insects, and animals.	Sites	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.

ADDITIONAL HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

REQUIRED PPE	Safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE MSDS	MSDSs will be maintained based on site characterization and contaminants. Nitric acid.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT
The following documents should be referenced to assist in completing the associated task.

P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	
TOOLS	5-gallon bucket of tap water, stiff brush, soap, de-ionized or distilled water, nitric acid (if required), plastic sheeting or foil, tarps, decontamination tubs and buckets, and sprayers.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE

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SOP TECHNICAL AUTHOR	**DATE**
SAFETY AND HEALTH MANAGER	**DATE**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for sampling with a bailer.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
1. Determine water level in the well.	Using clean, non-contaminating equipment (e.g., an electronic depth to water level indicator (avoid indicating paste)) (per SOP-DE-02 Equipment Decontamination), determine the water level in the well. Refer to SOP-GW-03 Depth to Water Level Measurements for instructions. If required, check for the presence of free or floating product with an interface probe or clear bailer. Calculate the fluid volume in the casing and determine the appropriate volume of water to be purged prior to any sample collection.
2. Collect sample with bailer.	Attach a clean, decontaminated bailer to clean line for lowering and raising the bailer into the well. A disposable or dedicated bailer is preferred. Make sure the knot will not come loose. Lower bailer slowly until it contacts water surface. The bailer should not contact the bottom of the well. Allow bailer to sink slowly and fill with a minimum of surface disturbance. Slowly raise bailer to surface. Do not allow bailer line to contact the ground surface.
3. Discharge purged water into appropriate container.	Use bottom discharge device to slowly discharge purged water into an appropriate container, or pour slowly from top of bailer. Purged water shall be disposed of in accordance with the site-specific Sampling and Analysis Plan (SAP), client disposal requirements and/or SOP-DE-03 Investigation Derived Waste Handling.
4. Acquire sufficient purge volume.	Repeat task #2 as needed to acquire sufficient purge volume.

5. Pour water into appropriate containers.	Once sufficient purge volume has been collected, use bottom discharge device or pour slowly from top of bailer into appropriate sample containers.
6. Acquire sufficient sample volume.	Repeat task #2 as needed to acquire sufficient sample volume.
7. Preserve and cap the samples.	If water is being collected for volatile organic compounds (VOCs) analysis, place preservative in vials (if appropriate, prior to filling). Check that a Teflon liner is present in cap if one is required. After filling, secure the cap tightly. Check for air bubbles. To check for air bubbles: turn the VOC bottle upside down, tap lightly, turn right side up, see if any bubbles float to the top. If you see a bubble, remove lid, add additional water, and reseal.
8. Label the samples.	Label the sample bottle with an appropriate tag/label. Be sure to complete the tag with necessary information. Record the information in the field logbook and complete all chain-of-custody documents.
9. Transport the samples.	Place the properly labeled sample bottle in an appropriate carrying container maintained at 4°C +/- 2°C throughout the sampling and transportation period.
10. Decontaminate bailer.	Decontaminate bailer thoroughly after each use according to SOP-DE-02 Equipment Decontamination.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated soils and water.	Sites.	Inadvertent exposure to contaminated soils and water could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves and safety glasses when collecting and handling samples. Pour water from bailer into bucket, or from bucket into disposal area slowly to prevent splashes and skin contact.
	Preservatives (HCL, HNO3,H2SO4, Zinc, Acetate, NaOH)	In bottles or added to bottles through sampling process	Inadvertent exposure to preservatives could lead to adverse health effects.	Safety Data Sheets for each preservative chemical are available to all employees on the Pioneer company web site. Personnel will wear nitrile gloves and safety glasses when adding preservatives to sample bottles. Refer to the Chemical Flushing Guidelines available inside vehicle's first aid kit for first-aid procedures in case of contact with preservatives.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Improper lifting and carrying tools, equipment, and/or samples.	Sites.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry tools, equipment, and/or samples.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height.
	Bending, squatting, and kneeling.	During sample collection.	Bending, squatting, and kneeling during	Employees should stretch prior to starting work and they will take breaks when necessary.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
			sample collection could result in muscle/back strains or other injuries.	
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.
WEATHER	Cold/heat stress. Lightning.	Sites. Outdoor sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke. Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP. Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals	Training on the signs and symptoms of exposure to plants, insects, and animals is

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
			may cause rashes, blisters, redness, and swelling.	required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Pinch points.	Well caps.	Personal injury could result from fingers getting pinched in well caps.	Personnel will wear leather gloves when removing well caps.
	Sharp tools/equipment.	Sites.	Personal injury could occur while using a knife to cut bailer line.	Personnel will use proper tools for the job. Workers cannot use leather gloves while cutting the bailer line because of the potential for cross contamination. Use extreme caution and cut away from the body. Use approved cutting device.
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Struck by and/or caught in between heavy equipment or vehicles.	Sites.	Personnel could be injured if struck by and/or caught in between heavy equipment or vehicles while collecting samples.	Employees will communicate with the contractors on site. Personnel will avoid working near heavy equipment/vehicles, when possible. Personnel will wear high visibility clothing. When possible, personnel will park field vehicles or use traffic cones to prevent third

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
				party vehicles from coming into the work area.

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDS	HCL, HNO3, H2SO4, Zinc, Acetate, and NaOH. Additional Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-DE-02 Equipment Decontamination, SOP-DE-03 Investigation Derived Waste Handling, and SOP-GW-03 Depth to Water Level Measurements.
TOOLS	Electronic depth to water level indicator, disposable or dedicated bailer, buckets, sample bottles, clean string, and field logbook.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**12/03/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**12/03/2014**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for conducting depth to water level measurements.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Electric Depth to Water Indicator	
1. Inspect well casing.	Inspect well and casing for a marked measuring point. If no measuring point is marked, locate the north side of the well and establish a marking point. Choose the point for ease of accurately reading the measuring tape.
2. Test the water level indicator.	Test that the water level indicator is on and working by pushing the test button on the indicator and checking the buzzer sound level and/or checking for the light. Make sure the equipment is clean and decontaminated per SOP-DE-02 Equipment Decontamination.
3. Lower the sensor.	Lower the sensor probe slowly into the well to minimized disturbance of water when it is encountered. As the sensor is lowered down the well, the buzzer and/or flashing light will indicate contact with water. Be aware that sensor may indicate water prior to actual water level, if the probe contacts condensation on the well casing.
4. Align probe cable.	Once the buzzer has sounded, align the marked probe cable with the designated marking point and gently raise and lower the probe until the exact mark on the probe cable, when water is encountered, is identified.
5. Record information.	Record this information in the project logbook as the depth to water (DTW). In addition, record where the marking point was located (e.g., top of casing [TOC], top of PVC [TOPVC], inner PVC [IPVC]) to help maintain continuity, if subsequent DTW readings are needed from this well.
6. Reel in equipment.	Reel in sensor probe.

7. Decontaminate equipment.	Decontaminate all equipment prior to re-use per SOP-DE-02 Equipment Decontamination.
Chalked Measuring Tape Depth to Water Measurements	
1. Coat tape with chalk.	Make sure the equipment is clean and decontaminated per SOP-DE-02 Equipment Decontamination. Coat the lower three to five feet of tape with chalk and lower into well. Listen for weight to contact water and lower tape an additional 0.5 foot.
2. Record information.	Record measure point and pull tape carefully from well. Read the wetted chalk mark and record. Subtract the wetted chalk mark from the measure point for true depth to water.
3. Decontaminate equipment.	Decontaminate all equipment prior to re-use per SOP-DE-02 Equipment Decontamination.

HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated water.	Sites.	Inadvertent exposure to contaminated soils and water could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves and safety glasses when collecting and handling samples.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Bending, squatting, and kneeling.	During depth measurements.	Bending, squatting, and kneeling during depth measurements could result in muscle/back strains or other injuries.	Employees should stretch prior to starting work and they will take breaks when necessary.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.

	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites and well casings.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Scrapes and cuts.	Well casing.	Scrapes and cuts could result, when taking measurements, from sharp edges in metals or PVC casings.	Employees will inspect well casing for sharp edges. If edges are very sharp, employees will wear leather gloves.
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.

SIMOPS	Struck by and/or caught in between heavy equipment or vehicles.	Sites.	Personnel could be injured if struck by and/or caught in between heavy equipment or vehicles while collecting samples.	Employees will communicate with the contractors on site. Personnel will avoid working near heavy equipment/vehicles, when possible. Personnel will wear high visibility clothing. When possible, personnel will park field vehicles or use traffic cones to prevent third party vehicles from coming into the work area.

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDS	Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	Map with well locations.
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-DE-02 Equipment Decontamination.
TOOLS	Water level indicator or measuring tape and chalk, and field logbook.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang	**12/03/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman	**12/03/2014**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for purging and sampling with a peristaltic pump.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Note	Sampling wells in order of increasing chemical concentrations is preferred.
1. Determine the water level in the well.	Using clean, non-contaminating equipment (e.g., an electronic depth to water level indicator (avoid indicating paste)), per SOP-DE-02 Equipment Decontamination, determine the water level in the well. Refer to SOP-GW-03 Depth to Water Level Measurements for instructions. Calculate the fluid volume in the case (“casing volume”) and record in the logbook. If depth to mid-point of screen is over 8 meters, choose alternative system.
2. Measure tubing to be used.	Measure the appropriate amount of disposable or decontaminated tubing to be inserted into the well. Add an additional two to four feet of tubing that will remain outside the well and attach to the soft tubing in the peristaltic pump. Teflon or Teflon lined tubing is preferred when sampling for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyl (PCBs). Polyvinyl chloride (PVC), polyethylene and polypropylene tubing can be used when sampling for inorganics.
3. Insert tubing into the well.	Insert the tubing into the well to the predetermined sampling zone. The mid-point of the saturated screen is used by convention as the location of the tubing end. Chemical concentrations or permeability considerations may require tubing placement in a different zone. This will be indicated in the Sampling Analysis Plan (SAP) or work plan. If possible keep the tubing at least 2 feet from the bottom of the well to avoid mobilization of particulates in the bottom of the well.
4. Measure and record the discharge rate.	Insert the soft tubing into the peristaltic pump following the instructions in the operating manual. Insert the hard tubing into the soft tubing end. Start the pump head and adjust the pump speed until an appropriate discharge rate is achieved. The pump should discharge at an extraction rate that avoids drawing down the water level below the pump intake. Measure the discharge rate using a bottle or beaker and a stop watch. Record this information in the logbook. If the recharge rate is slower than an attainable extraction rate using the pump and the well becomes

	essentially dewatered (e.g., water level falls below the intake level), the well should be allowed to recover sufficiently to fill all the appropriate sample containers. If possible, do not move the pump intake during this process. Samples may then be collected.
5. Dispose of purged water and record total purge volume.	Collect and dispose of purged water in accordance with SOP-DE-03 Investigation Derived Waste Handling. Measure and record the total purge volume.
6. Monitor and record field parameters and depth to water level measurements.	During well purging, monitor indicator field parameters including pH, conductivity, and temperature. The SAP or work plan may indicate other field parameters that need to be monitored, such as eH, dissolved oxygen (DO), and turbidity. Water quality parameters will be considered stable when three consecutive readings (generally 2-5 minutes apart) are as follows: a. Temperature range is no more than +/- 1 degree Celsius (°C); b. pH varies by no more than 0.1 pH units; and c. Specific conductivity readings are within 3% of the average. Field parameters should be recorded in the logbook or on field data sheets.
7. Collect samples.	Purge a minimum of three casing volumes and/or until water quality parameters stabilize. Once these conditions occur, sampling can commence. In general, VOC samples should not be collected when using a peristaltic pump. If VOC analysis is required, collect the VOC samples first and then place them directly into pre-preserved sample containers. Fill the sample containers by allowing pump discharge to flow gently down the side of the bottle with minimal entry turbulence. Double check for bubbles as this method tends to produce them. Cap each bottle as filled. Add preservative as required by analytical methods to samples immediately after collection, if not collected in pre-preserved containers. If a filtered sample is required, an in-line high capacity (0.45 µm) should be inserted into the discharge end of the soft tubing after the other sample containers are filled. Fill the sample bottle and preserve immediately; cap the bottle. To check for air bubbles: turn the VOC bottle upside down, tap lightly, turn right side up, see if any bubbles float to the top. If you see a bubble, remove lid, add additional water, and reseal.
8. Label sample bottles.	Label the sample bottle with an appropriate tag/label. Be sure to complete the tag with necessary information. Record the information in the field logbook and complete all chain-of-custody documents.
9. Transport sample bottles.	Place the properly labeled sample bottles in an appropriate carrying container maintained at 4°C +/- 2°C throughout the sampling and transportation period.

10. Dispose of used tubing.	Tubing used in the well sampling will be disposed of in accordance with SOP-DE-03 Investigation Derived Waste Handling.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated soils and water.	Sites.	Inadvertent exposure to contaminated soils and water could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves and safety glasses when collecting and handling samples. Pour water from bucket into disposal area slowly to prevent splashes and skin contact.
	Preservatives (HCL, HNO3, H2SO4, Zinc, Acetate, NaOH).	In bottles or added to bottles through sampling process.	Inadvertent exposure to preservatives could lead to adverse health effects.	Safety Data Sheets for each preservative chemical are available to all employees on the Pioneer company web site. Personnel will wear nitrile gloves and safety glasses when adding preservatives to samples bottles. Refer to the Chemical Flushing Guidelines available inside vehicle's first aid kit for first-aid procedures in case of contact with preservatives.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Improper lifting.	Testing sites.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry tools and equipment.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two people will lift objects, if necessary.
	Bending, squatting, and kneeling.	During sample collection.	Bending, squatting, and kneeling during sample collection	Employees should stretch prior to starting work and they will take breaks when necessary.

			could result in muscle/back strains or other injuries.	
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available

				on site. Employees with allergies will notify their supervisor.
MECHANICAL	Pinch points.	Well caps.	Personal injury could result from fingers getting pinched in the well cap.	Personnel will wear leather gloves when removing well caps.
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Struck by and/or caught in between heavy equipment or vehicles.	Sites.	Personnel could be injured if struck by and/or caught in between heavy equipment or vehicles while collecting samples.	Employees will communicate with the contractors on site. Personnel will avoid working near heavy equipment/vehicles, when possible. Personnel will wear high visibility clothing. When possible, personnel will park field vehicles or use traffic cones to prevent third party vehicles from coming into the work area.

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, nitrile gloves, and leather gloves.
APPLICABLE SDS	HCL, HNO3, H2SO4, Zinc, Acetate, and NaOH. Additional Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.

ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	Map with site location and sample locations.
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-DE-02 Equipment Decontamination, SOP-DE-03 Investigation Derived Waste Handling, and SOP-GW-03 Depth to Water Level Measurements.
TOOLS	Sample bottles, water quality meters, 5-gallon buckets, electronic depth to water level indicator, peristaltic pump, stop watch, cooler, and field logbook.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**12/11/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**12/11/2014**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for groundwater monitoring well design and construction.
SCOPE	This practice is for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed procedure described below.
NOTE	A set procedure for designing and constructing groundwater monitoring wells cannot be presented as a standardized operating procedure. Every location within a site may vary depending on contamination encountered, lithology of the subsurface, and depth to groundwater. A technique that may work at one location may be inappropriate at the next. The following sections discuss general guidelines for well design and construction, but actual well designs will depend on specific site conditions and the associated contaminants of concern. Wells drilled for a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) investigation will be designed to specifications suggested by the site being investigated, provided such design presents no conflict with investigation sampling objectives. This policy will permit the site to incorporate any new wells into on-going monitoring programs by ensuring that new wells are constructed in the same manner as existing wells. Conflicts may result when existing well construction is not suitable for the proposed sampling. For example, polyvinyl chloride (PVC) casing will not be used, if the site is contaminated with high-concentrations of organic compounds, even though existing wells contain PVC casings. Such conflicts will be resolved on a site-specific, case-by-case basis. The method of well construction and the materials used in the casing and screen affect the quality of the well, and its utility for groundwater monitoring, throughout its lifetime. The elements of proper monitoring well construction presented serve as guides for any wells constructed for the groundwater investigation. In addition, these guidelines can be applied to evaluate the adequacy of existing wells when sampling will be conducted from available wells.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work performed under this Standard Operating Procedure (SOP) will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
1. Coordinate utility locates.	Prior to starting work, the drilling subcontractor will have a utility locate and marking performed.
2. Conduct a site walk.	Verify utility locates have been performed. Walk through the site and determine any site-specific hazards associated with the work area. Discuss these hazards with site personnel and note them in the field logbook. Verify the utility locate information

	by identifying where natural gas pipes or other utilities enter any structures on the property or if yard lights or street lights are present with no overhead lines.
3. Select well diameter.	The diameter of the well casing will be the minimum that allows the sampling and/or monitoring equipment to be lowered to the desired depth. The diameter of the borehole into which the casing is placed must be large enough for the casing to fit and have sufficient annular space for the addition of a filter pack and well seal. The diameter of the borehole should be at least 4 inches larger than the casing to provide a minimum 2-inch annular space. When using direct push methods for well installation, the use of prepacked well screens and foam bridge/prepacked bentonite seals are necessary to install wells in smaller boreholes under saturated conditions.
4. Determine well depth.	Wells will be constructed to be depth discrete and to be sampled from one aquifer zone without interference from other zones. This requires provisions for grouting above, and if necessary, below the well screen on the outside of the casing. The location of the screen will be important for sampling since it has an impact on sampling of immiscible organics. Sampling of less dense or more dense organics, which float or sink, will require the screen to be placed at the appropriate depth.
5. Select well casings and screens.	Well casings and screens will be constructed of materials with the least potential for affecting the water quality parameters of the sample. Guidance/criteria regarding casing and screen material selection is presented in various U.S. Environmental Protection Agency (EPA) guidance documents. Well casings and screens will be cleaned and protected from contamination prior to their installation. Factory cleaned screen and casing stored in plastic protective wrap may be used instead of field decontamination of well materials. Selection of screen and slot style are important factors in screen selection. Saw-slot style screens offer less screen open area than the Vee-wire continuous wrap screens making the saw-slot screens far less efficient in terms of producing water. Pre-packed wells screens available from many vendors offer the alternative to set well screen and filter pack in one operation, guaranteeing accurate filter pack placement.
6. Define well drilling method.	Drilling method selection will be based on minimizing both the disturbance of the geologic materials penetrated, and the introduction of air, fluids, and muds. Additionally, some drilling methods are better at collecting soil samples during drilling operations for subsurface characterization. Rotary sonic is one such method that collects quality soil cores for logging and characterization purposes. The direct push technology has also become increasingly popular for the installation of small diameter wells that significantly decreases the volumes of investigation derived waste. Mud rotary drilling that utilizes either bentonite or a polymer-based drilling muds will be avoided. Advantages and disadvantages of various drilling methods are also discussed in EPA guidance documents.
7. Select monitoring well filter pack and annular sealant.	The materials used to construct the filter pack should be chemically inert (e.g., clean quartz sand, silica, or glass beads), well rounded, and dimensionally stable. Natural gravel packs are acceptable, provided that a sieve analysis is performed to establish the appropriate well screen slot size and determine chemical inertness of the filter

pack materials in anticipated environments. Typically, 10-20 mesh silica sand is used to construct most monitoring wells utilizing screens with slot sizes of 0.010 or 0.020 inches. The prepack well screen option typically uses 0.010-inch slotted screen with 20-40 mesh silica sand contained within an outer layer of 65 mesh stainless steel screen.

The materials used to seal the annular space must prevent the migration of contaminants from the surface or intermediate zones to the sampling zone and prevent cross contamination between strata. The materials should be chemically compatible with the anticipated contaminants to ensure seal integrity during the life of the monitoring well and chemically inert so they do not affect the quality of the groundwater samples. The permeability of the sealants should be one to two orders of magnitude less than the surrounding formation. An example of an appropriate use of annular sealant material is using a minimum of 2 feet of certified sodium bentonite pellets immediately over the filter pack when in a saturated zone. Bentonite pellets are best used in a saturated zone because they will sink in the column of water before hydrating and create an effective seal. Deep water columns may require the use of coated bentonite pellets to allow the bentonite to sink before hydrating. Coarse grit sodium bentonite is likely to hydrate in the water column and bridge before reaching the filter pack and therefore should only be used to install seals above the water table. A cement and bentonite mixture, bentonite chips, or anti-shrink cement mixtures may be used as the annular sealant in the unsaturated zone above the certified-bentonite pellet seal and below the frost line. The addition of bentonite to the cement admixture should generally be in the amount of 2 to 5 percent by weight of cement content. This will aid in reducing shrinkage and control time of setting. However, field experience has demonstrated that pure bentonite installed in the vadose zone forms a better well seal as opposed to the cement-based seals that are prone to fracturing over time. Again, the appropriate clay seal material must be selected on the basis of the environment in which it is to be used. In most cases, sodium bentonite is appropriate. Calcium bentonite may be more appropriate in calcic sediments/soils due to reduced cation exchange potential. Clays based seals should be pure (i.e., free of additives that may affect groundwater quality).

The untreated clay seal should be placed around the casing either by dropping it directly down the borehole or, if a hollow-stem auger is used, putting the bentonite between the casing and the inside of the auger stem. The use of a granular bentonite facilitates the installation of the well seal where the annular space is limited, and the use of bentonite chips presents bridging risks. In shallow monitoring wells, a tamping device or slender rod system should be used to reduce this potential of bridging. Generally, a spacing differential of 3 to 5 inches should exist between the outer diameter of the casing and the inner diameter of the auger, or the surface of the borehole to facilitate emplacement of filter pack and annular sealant. The actual volume of materials used should be recorded during well construction and compared to the calculated volume. Discrepancies between calculated volumes and volumes used require an explanation.

If a cement-bentonite seal mixture is specified, the mix should be prepared using clean water and placed in the borehole using a tremie pipe. The tremie method ensures good sealing of the borehole from the bottom.

	Upon completion of the well, installation of a suitable threaded or flanged cap or compression seal should be placed or locked in properly to prevent either tampering with the well or the entrance of foreign material into it. A ¼-inch vent hole pipe provides an avenue for the escape of gas, if a totally submerged well screen is installed. Placement of concrete or steel bumper guards around the well will prevent external damage by a vehicular collision with the exposed casing.
8. Design well screen.	The intake of the monitor well should be designed and constructed to: 1) allow sufficient groundwater flow into the well for sampling; 2) minimize the passage of formation materials (turbidity) into the well; and 3) ensure sufficient structural integrity to prevent the collapse of the intake structure. For wells completed in unconsolidated materials, the intake of a monitoring well should consist of a screen or slotted casing with openings sized to minimize the amount of formation material from passing through the well during development. Extraneous fine-grained material (e.g., clays and silts) that has been dislodged during drilling may be left on the screen and in the well water. These fines should be removed from the screen and filter pack during development of the well. Commercially-manufactured screens or slotted casings should be used; field slotting of screens is not acceptable.
9. Develop well.	After the installation of the monitoring well, the natural hydraulic conductivity of the formation should be restored, and all foreign sediment removed to ensure turbid-free groundwater samples. A variety of techniques are available for developing a well. To be effective, they require reversals or surges in flow to avoid bridging by particles, which is common when flow is continuous in one direction. These reversals or surges can be created by using surge blocks, bailers, or pumps. Formation water should be used for surging the well. Any contaminated waters produced during development will be containerized for proper disposal. In low-yielding water-bearing formations, an outside source of water may sometimes be introduced into the well to facilitate development. In these cases, this water should be chemically analyzed to evaluate its potential impact on in-situ water quality. The driller should not used air to develop the wells. All developing equipment and materials need to be decontaminated prior to developing the well. Refer to SOP-GW-12 Well Development Using a Modified Over-Pumping Technique for more information.
10. Document well design and construction.	Information on the design and construction of wells will be documented and may include: • Date/time of construction. • Drilling method and drilling fluid used. • Well location (± 0.5 feet). • Borehole diameter and well casing diameter.

- Well depth (± 0.1 feet).
- Drilling and lithologic logs.
- Casing materials.
- Screen materials and design.
- Casing and screen joint type.
- Screen slot size/length.
- Filter pack material/size, grain analysis (D10).
- Filter pack volume calculations.
- Filter pack placement method.
- Sealant materials (percent bentonite).
- Sealant placement method.
- Surface seal design/construction.
- Well development procedure.
- Type of protective well cap.
- Ground surface elevation (± 0.01 feet).
- Surveyor's pin elevation (± 0.01 feet) on concrete apron.
- Top of monitoring well casing elevation (± 0.01 feet).
- Top of protective steel casing elevation (± 0.01 feet).
- Detailed drawing of well (include dimensions).

Specialized Well Designs

There are two cases where special monitoring well design will be used:

- Where it has been decided to use dedicated pumps to draw groundwater samples.
- Where light and/or dense immiscible phases may be present.

If it is elected to use a dedicated system, it should be a fluorocarbon resin or stainless-steel bailer, or a dedicated positive gas displacement bladder pump composed of the same two materials. As other sampling devices that can perform at least equivalently become available, they may be employed as well.

The introduction of this pump, however, necessitates certain changes in the well. The principal change is the addition of a 2-inch diameter pump with fluorocarbon resin outlet tubing to the well. A 4-inch interior diameter outer well casing should easily accommodate this additional equipment. However, should a larger pump (e.g., 3 inches in diameter) be required because of greater well depth or yield, a larger outer casing may prove necessary (6-inch inside diameter). The pump should be positioned midway along the screened interval, and the top of its outlet pipe should extend into the well cap.

If light or non-aqueous phase liquids (L-NAPLs) or dense non-aqueous phase liquids (D-NAPLs) layers are presumed to be present, discrete samples must be obtained. The well system needs to be designed to allow sampling of light or dense phases by using a well screen that either extends from above the potentiometric surface for the L-NAPL sampling or slightly into the lower confining layer for DNAPL monitoring. Where well clusters are employed, one well in the cluster may

	be screened at horizons where floaters are expected, another at horizons where dense phases are expected, and others within other portions of the uppermost aquifer. A periodic check of the dedicated sampling system should be exercised to prevent damage and maximize efficiency. This inspection should include removal of samples for verification of proper function. The design of the dedicated sampling system should also allow access for regular testing of aquifer characteristics. It is also recommended that the well be periodically resurveyed using the protective casing and apron as points of reference. An option that can be exercised in constructing a monitoring well (e.g., dedicated sampler) is the use of fine sand at the top of the filter pack to reduce or minimize invasion.

HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated soils and water.	Sites.	Inadvertent exposure to contaminated soils and water could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Personnel will wear nitrile gloves and safety glasses when contact with soils and water is possible.
	Exposure to hydraulic fluids.	Drilling operations.	Exposure to hydraulic fluids could occur while operating and working around the drill due to equipment malfunction/ failure resulting in personal injuries.	The operator will inspect the drill and document inspections daily before starting work. The operator will also replace/repair all faulty equipment before starting work. When inspecting equipment, personnel will wear work gloves to prevent possible exposures to hydraulic fluids. Non-essential personnel will maintain a 20-foot buffer zone around the drill.
	Contact with gasoline/diesel.	Fueling equipment.	Inadvertent exposure via inhalation and/or skin contact can result in adverse health effects and skin irritation.	Personnel will fuel the equipment in a well-ventilated area, stand up wind while fueling, and minimize splash hazards so skin contact does not occur.
	Exposure to annular sealant material (e.g., bentonite and cement).	Sealing the annular space of wells.	Personnel could be exposed to annular sealant material via inhalation of material dust and/or direct skin/eye contact, which could result in personal injuries such as irritation of the	To prevent exposure, pour material slowly, stay upwind, and wear work gloves and safety glasses. If contact occurs, personnel will thoroughly wash the affected area with water and flush their eyes.

CHEMICAL			respiratory system, skin, or eyes.	
NOISE	Elevated noise levels.	Drilling operations.	Personnel could be exposed to elevated noise levels when operating the drill and working near drilling operations resulting in hearing damage.	Personnel will wear hearing protection (e.g., ear plugs) when operating and working near the drill. Non-essential personnel will maintain a 20-foot buffer zone around the drill when possible. Hearing protection will be administered and used in accordance with the policies and procedures outlined in the Pioneer Corporate HASP.
ELECTRICAL	Contact with underground and/or overhead utilities.	Sites.	Injury, death or property damage could occur from equipment contact with underground and/or overhead utilities while drilling boreholes.	Personnel will follow the underground and overhead utilities procedures as outlined in the Pioneer Corporate HASP. Personnel will avoid areas with underground and overhead utilities hazards as much as possible.
BODY MECHANICS	Bending, squatting, and kneeling.	During fieldwork activities.	Bending, squatting, and kneeling during fieldwork activities could result in muscle/back strains or other injuries.	Personnel should stretch prior to starting work and they will take breaks when necessary.
	Improper lifting.	Sites.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry tools and equipment.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two workers will lift/handle heavy items.

GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces, and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Personnel will wear work boots with good traction and ankle support. They will plan their path and walk cautiously. If using bentonite as annular sealant, avoid bentonite contact with water on the ground. Pour the bentonite slowly to prevent spills and slippery surfaces.
WEATHER	Cold/heat stress.	Outdoor sites.	Exposure to cold climates may result in cold burns, frostbite, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors (e.g., layers and loose clothing). Personnel will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in the applicable SSHASP and/or Pioneer Corporate HASP.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Personnel will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoor sites.	Personnel could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Personnel will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Personnel should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Outdoors.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First aid kits will be available in company vehicles. Personnel with allergies will notify their supervisor.

MECHANICAL	Pinch points.	During fieldwork activities.	Personnel could be exposed to pinch points when opening and closing gates, vehicle doors, carrying cases, and well caps or when using hand tools and equipment resulting in personal injuries such as scrapes, cuts, and broken fingers.	Personnel will be aware of finger/hand placement and not put fingers/hands between objects. Personnel will also wear work gloves to protect against pinch-point injuries and inspect all tools/equipment prior to each use.
	Rotating parts of the drill.	Drilling operations.	Inadvertent contact with rotating parts could result in fingers/hands becoming pinched or caught causing scrapes, cuts, and/or broken bones.	Personnel will avoid touching rotating parts of the drill. The drill operator and helpers will not wear loose clothing/jewelry. Personnel will know the location of all emergency shutoffs on the drill. Non-essential personnel will maintain a 20-foot buffer zone around the drill when possible.
PRESSURE	Pressurized hydraulic hoses.	Drilling operations.	Hydraulic hoses could burst/rupture resulting in inadvertent contact with hydraulic fluid or personal injury due to being struck by hoses.	The operator will inspect the drill and document inspections daily before starting work. The operator will also replace/repair all faulty equipment before starting work. When inspecting equipment, personnel will wear work gloves to prevent possible exposures to hydraulic fluids. Non-essential personnel will maintain a 20-foot buffer zone around the drill.
THERMAL	Hot surfaces.	Drilling operations.	The equipment components could become hot during drilling operations and direct contact	Personnel will avoid contact with hot surfaces, and they will wear work gloves as needed.

			with these components could cause skin injuries.	
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced personnel and improper training could cause incidents resulting in adverse health effects and/or property damage.	Personnel will be properly trained in the procedure described above and other applicable procedures. Personnel will follow the stop work policy, if there are any issues.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	**Personal Protective Equipment** (PPE): Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, nitrile gloves, and leather gloves.
APPLICABLE SDSs	**Safety Data Sheets** (SDSs) will be maintained based on the site characterization and contaminants.
REQUIRED PERMITS/ FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
DRAWINGS	Map with site location and well locations.
RELATED SOPs/ PROCEDURES/ WORK PLANS	SOP-GW-12 Well Development Using a Modified Over-Pumping Technique.
TOOLS	Varies depending on selected drilling technique.
FORMS/ CHECKLIST	Field logbook and well installation log.

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Ken Manchester	**04/23/2018**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman	**04/23/2018**

PURPOSE	To provide standard instructions for well development and the removal of fine grained sediments from the vicinity of the well screen. Well development allows the water to flow freely from the formation into the well and reduces the turbidity of the water during groundwater sampling. Initial well development is critical to ensure that the well has the pumping volume required for future use.
SCOPE	This practice is for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed procedure described below. This Standard Operating Procedure (SOP) discusses well development using a modified over-pumping technique and can be used with the following pumps: peristaltic, low flow Grundfos, PROACTIVE 12-volt submersible, and Grundfos Redi-Flo II. Less vigorous methods of well development include bailers or manual surge blocks. These methods are addressed in other SOPs. If a well requires more vigorous development than over-pumping (e.g., soil types, chemicals used during installation, large required production volumes, etc.), a well installer or subcontractor may be required to complete the development.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work performed under this Standard Operating Procedure (SOP) will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
1. Select pump.	The table below summarizes the types of pumps Pioneer has readily available for well development. Personnel should select the appropriate pump for the well development required using the table below.

Pump/ Development Type	Well Diameter (inches)	Max Well Depth (ft)	Anticipated Production
Bailer[1]	1	100	Poor to Good
	≥2	100	Poor
Manual Surge Block[1]	1	100	Poor to Good
	≥2	100	Poor
Peristaltic Pump	1	25	Poor to Good
	2	25	Poor
Low Flow Grundfos	≥2	200	Poor to Good
PROACTIVE 12-volt Submersible Pump	≥2	80	Good
Grundfos Redi-Flo II	≥2	250	Good
Subcontractor/Well Installer	≥2	>250	Poor to Good

1. If a bailer or manual surge block is the only alternative, the modified over-pumping technique cannot be used. Instead, personnel should follow the appropriate, alternative SOP.

2. Gather information.	Review the Site Sampling and Analysis Plan (SAP) or Work Plan for purge water containment requirements. Compile the necessary equipment and well installation information (e.g., total depth, screen interval, etc.) prior to traveling to the site.
3. Set up equipment.	Upon arrival at the well/piezometer to be developed, place the containers that will be used to contain purge water (if required) in an accessible location. Set up the remainder of the equipment adjacent to the well, within spill containment if required.
4. Take and initial DTW reading.	Open the well/piezometer and take an initial depth to water (DTW) reading following the instructions outlined in SOP-GW-03 Depth to Water Level Measurements. Record the initial DTW in the field logbook and on the well development field data sheet.
5. Check the total depth of the well.	Check the total depth of the well by turning off the buzzer on the DTW meter and lowering probe to the bottom of the well. Record this information in the field logbook and on the well development field data sheet. Remove the DTW probe from the well. Record the screen depth and length (available from the well installation log).
6. Set up pump and tubing.	If needed, attach an appropriate length of disposable or decontaminated tubing to the pump outlet or put tubing in the pump head. Don a new, clean pair of gloves prior to handling the tubing. Lower pump or tubing into the well. The pump intake should be located near the bottom of the screened interval. If the screen extends to the bottom of the well, make sure the intake for the pump is located above any slurry that may be present in the bottom of the well, approximately 1/2 to 1 foot above the bottom if using the submersible pumps.

	If using a peristaltic pump, tubing can be located closer to the bottom of the well as slurry will only clog the tubing and not damage the pump itself. If using a submersible 12-volt pump without a controller, put a valve on the discharge end of tubing and securely fasten. Record the depth of the pump intake in the field logbook and on the well development field data sheet.
7. Measure DTW with the pump installed.	Put the DTW probe back in the well and make sure it is turned on. Record the DTW with the pump installed.
8. Turn the pump on and adjust water flow.	If using a 12-volt submersible pump, start the pump with the attached discharge valve all the way open. If using a Grundfos pump with a controller or a peristaltic pump, turn the pump on and raise the pumping rate slowly until water starts to flow. Monitor the DTW meter; the water elevation should drop until the tubing is full and water is flowing freely. If the water elevation continues to drop after water is flowing smoothly, turn flow down using either the discharge valve or the controller until the water elevation stabilizes. Record the time development starts, the stabilized water elevation, and an estimate of volume purged in the field logbook and on the well development field data sheet as "Initial Drawdown."
9. Measure the stabilized water flow rate.	Measure the stabilized water flow rate using an appropriately-sized container (e.g., graduated cylinder, marked beaker, marked bucket, etc.) and a stopwatch to determine the volume of water per minute being purged from the well. Record the water flow rate in the field logbook and on the well development field data sheet.
10. Record the characteristics of the purged water.	Record the color of water, presence of sand or silt, and any odors or sheen. If the water is not extremely dirty, run an initial turbidity measurement and record.
11. Track the volume of water being removed.	Track the volume of water being removed. Volume may be calculated by either multiplying the elapsed time by the water flow rate or multiplying the number of buckets/drums purged by the volume of the bucket/drum. Keep a record of time, water removed, turbidity measurements and DTW readings in the field logbook and on the well development field data sheet.
12. Measure and record the field parameters.	Once the water appears to be clear, begin measuring field parameters. At a minimum, measure temperature, pH, specific conductivity (SC), and turbidity. If required by the SAP or Work Plan, measure and record the oxidation reduction potential (ORP) and dissolved oxygen (DO). Depending on the water flow rate field parameter probes can be placed in a 5-gallon bucket, in a ½- to 1-liter beaker or in a flow thru cell. Turnover of water in the container should be quick (e.g., 1 to 2 minutes). As an example, if the water is purging

	at 4 gallons a minute, a 5-gallon bucket could be used, as turnover in the bucket would be about 1 minute. If water is purging at 1 to 2 gallons a minute, a liter beaker may be more appropriate. If the water is fairly clear, a flow through cell with appropriately sized bypass tubing can be used with any flow rate. The flow through cell allows the water in the bypass tubing to be discharged directly into a storage container or to the ground a safe distance downgradient from the well. Record parameter measurements every 5 to 10 minutes. Record DTW measurements and estimated volume along with the parameter readings in the field logbook and/or on the well development field data sheet.
13. Purge the well and monitor drawdown.	If possible, when turbidity falls below 50 Nephelometric Turbidity Unit (NTU), increase the flow by adjusting the discharge valve or turning up the controller. Purge the well at about twice the stabilized water flow rate determined in Steps 8 and 9. Monitor drawdown constantly as you do not want to purge the well dry. • The water elevation may stabilize at a level lower than the initial DTW reading. If so, record how long it took to stabilize at the lower level, the amount of water purged, and the new DTW elevation in the field logbook and on the well development field data sheet. • If the water elevation in the well drops to about 4 to 5 feet above the pump intake (the acceptable drawdown elevation should be adjusted based on the water column, screen length and depth of the well being developed; ideally you want to develop the well along the entire screen length), turn the discharge valve or controller below the starting flow rate and allow the well to "recover." Record the duration, amount purged, and DTW when done with the initial over-pumping of the well. • If the pump is purging at maximum capacity, or if no drawdown occurs at a higher flow, turn the pump off, let the well "recover" for 1 to 5 minutes, and turn the pump back on. Record the duration of the stoppage and the new starting water level in the field logbook and on the well development field data sheet.
14. Continue monitoring turbidity and recording field parameters.	Turbidity may increase after the over-pumping or stopping. Continue recording field parameters unless the turbidity exceeds 1000 NTU. At this point, remove the field parameter probes and wait for the water to clear up before recording field parameters. Note this in the field logbook or on the well development field data sheet. Once turbidity measures less than 50 NTU, repeat Steps 12 and 13 until the clarity of water does not change significantly between lower and higher flows.
15. Adjust pump as needed.	If time permits (as designated in the SAP or Work plan) and the stabilized water level allows, raise the pump to the midpoint of the screen and repeat Steps 12 through 14, recording time, field parameters, volume purged, and DTW readings until turbidity readings are less than 50 NTU.
16. Continue monitoring turbidity and	The well is considered developed when 3 consecutive readings for turbidity are below the SAP or Work Plan designated requirements (e.g., the Clark Fork River Superfund Site Investigation SOP [ARCO, 1992] requires readings below 5 NTU, and the U.S.

field parameters to determine if the well is developed.	Environmental Protection Agency [EPA] well development protocol requires readings below 50 NTU) and the remaining required field parameters have stabilized. Water quality parameters are considered stable when three consecutive readings are as follows: • Temperature range is no more than +/- 1 degree Celsius (°C); • pH varies by no more than 0.1 pH units; and • SC readings are within 3% of the average.
17. Record the final DTW and calculate the total amount of water purged.	Before turning off the pump, record a final DTW. Calculate the total amount of water purged and record the volume in the field logbook and on the well development field data sheet.
18. Dispose of the purge water and tubing.	Dispose of the purge water and tubing as outlined in the SAP or Work Plan.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated soils and water.	During well development.	Inadvertent exposure to contaminated soils and water could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Personnel will wear nitrile gloves and safety glasses when contact with purge water is possible. Pour purge water from buckets into disposal area/containers used to contain purge water slowly to prevent splashes and skin contact. Keep control of high-flow discharge hoses to prevent water spraying and skin contact.
	Carbon monoxide (CO).	Generator.	Potential exposure to CO when working around the generator could result in irritated eyes, headache, nausea, weakness, and dizziness.	Personnel will stay up wind when working around the generator. The generator will not be operated indoors or near openings to any buildings that might be occupied.
	Contact with gasoline.	Fueling the generator.	Inadvertent exposure via inhalation and/or skin contact can result in adverse health effects and skin irritation if contact with gasoline occurs.	Personnel will fuel the generator in a well-ventilated area, stand up wind while fueling, and minimize splash hazards so skin contact does not occur. Wear nitrile gloves when removing the fuel cap and filter.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
NOISE	Elevated noise levels.	Using the generator.	Exposure to elevated noise levels from the generator may result in hearing damage.	Personnel will set up the generator away from the well development activities to prevent exposure to elevated noise levels.
ELECTRICAL	Improper use of the generator.	Sites (during we conditions).	Electrocution, shock, death, or equipment damage could be caused when using a generator during wet conditions.	If personnel must use a generator when it is wet outside, the generator will be protected from moisture and it will be equipped with a Ground Fault Circuit Interrupter (GFCI). Keep extension cord (if used) and connections as dry as possible. Place generator on a surface where water cannot puddle or drain under it. Personnel will dry hands, if wet, before touching the generator. Items will be connected to the generator using heavy-duty extension cords that are specifically designed for outdoor use.
	Improper use of the 12-volt battery.	Using the battery to power the 12-volt submersible pump.	Personal injuries could result from improper use and maintenance of a 12-volt battery. Example are: shocks, acid burns on skin or eyes, skin burns from electrical charge transfer through a tool and into a metal ring or watch, and battery explosions.	Personnel will remove all jewelry before working with a 12-volt battery. Personnel will disconnect the negative cable first and re-connect it last to prevent getting a shock from current overflow. Personnel will use the battery in well-ventilated areas and inspect the battery before and after each use. Personnel will wear leather gloves and safety glasses when handling the battery.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
BODY MECHANICS	Improper lifting.	During well development.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry tools and equipment.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two workers will lift/handle heavy items.
	Bending, squatting, and kneeling.	During well development.	Bending, squatting, and kneeling during work activities could result in muscle/back strains or other injuries.	Personnel should stretch prior to starting work and they will take breaks when necessary.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Personnel will wear work boots with good traction and ankle support. Personnel will be aware of walking/working surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. If conditions are wet or muddy, wear muck boots.
WEATHER	Cold/heat stress.	Outdoor sites.	Exposure to cold climates may result in cold burns, frostbite, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Personnel will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could result from lightning strike.	Personnel will follow the 30/30 rule during lightning storms.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
RADIATION	Ultraviolet (UV) radiation.	Outdoor sites.	Personnel could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Personnel will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Personnel should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Outdoors.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on the site. Personnel with allergies will notify their supervisor.
MECHANICAL	Pinch points.	Well caps.	Personal injury could result from fingers getting pinched in well caps.	Personnel will wear leather gloves when removing well caps.
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained personnel.	Sites.	Inexperienced personnel and improper training could cause incidents resulting in adverse health effects and/or property damage.	Personnel will be properly trained in the procedure described above and other applicable procedures. Personnel will follow the stop work policy, if there are any issues.
SIMOPS	Not applicable.			

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	**Personal Protective Equipment** (PPE): Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, nitrile gloves, and work gloves.
APPLICABLE SDS	**Safety Data Sheets** (SDSs) will be maintained based on the site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
DRAWINGS	
RELATED SOPs/ PROCEDURES /WORK PLANS	SOP-GW-03 Depth to Water Level Measurements
TOOLS	DTW meter, pump and tubing (see step 1 for pump selection), turbidity meter, container to measure water flow rate (e.g., graduated cylinder, marked beaker, marked bucket, etc.), stopwatch, field parameter meters, and containers to contain purge water (if required).
FORMS/ CHECKLIST	Field logbook, well development field data sheet, and well installation log.

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang (signature) **Julie Flammang**	**04/10/2018**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman (signature) **Tara Schleeman**	**04/10/2018**

PURPOSE	To provide standard instructions for setting up Geotech Multi-Probe Flowblock (Geotech Flowblock) flow through device for measuring field water quality parameters.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Notes	The Geotech Flowblock flow through device can be used directly in-line with most groundwater pumping systems such as the Grundfos RediFlo2™, Geotech SS Geosub, Geotech Bladder Pump, or Geopump Peristaltic Pump, and equivalent pumps. The Geotech Flowblock is designed for minimal sample volume (low-flow sampling) to reduce stirring dependence of sensors. The flowrate can vary from 100 mL/min to 1 gpm (3.8 L/min). **No laboratory samples will be taken from water that has flowed through the Geotech Flowblock or the quick-connect barbs.** Samples will be collected from tubing that was cut before contact with the Geotech Flowblock or the quick-connect barbs. The Geotech Flowblock does not need to be decontaminated between samples as it will not be in contact with laboratory samples. The Geotech Flowblock should be flushed between sample sites with tap or deionized (DI) water to flush out accumulated sediment. Refer to the following SOPs for the sampling setup in which the Geotech Flowblock will be used: SOP-GW-02 Sampling with A Bailer SOP-GW-10 Purging And Sampling with A 12-Volt Submersible Pump SOP-GW-10A Purging And Sampling with A Low Flow Submersible Pump SOP-GW-10B Purging And Sampling with Grunfoss Redi-Flow Submersible Pump SOP-GW-10C Purging And Sampling with A Peristaltic Pump SOP-GW-13 Sampling Groundwater From A Tap

	Prior to using the Geotech Flowblock, pH, specific conductivity, oxidation reduction potential (ORP), and dissolved oxygen (DO) field parameter meters need to be calibrated per the following SOPs: SOP-WFM-01 Field Measurement of pH In Water SOP-WFM-02 Field Measurement of Oxygen Reduction Potential in Water SOP-WFM-03 Field Measurement of Specific Conductance SOP-WFM-04 Field Measurement of Water Temperature SOP-WFM-07 Field Measurement of Dissolved Oxygen
1. (Option 1) Set up Geotech Flowblock.	The Option 1 set up is shown in Figure 1 below. This option can be used when using a pump that can be adjusted to a very low flow, such as the peristaltic pump and the low flow submersible pump. 1. Cut a piece of new silicon tubing. Use this tubing to connect the connecting valve to the Geotech Flowblock. Use a hose clamp to attach the tubing to the connecting valve. A hose clamp may also be needed to attach the tubing to the Geotech Flowblock. 2. Attach pump tubing to the connecting valve with a hose clamp. 3. Insert probes in the appropriate grommets in the Geotech Flowblock as depicted on Figure 1. Loosen the grommet to insert probes. The black cap on the pH and ORP columns (the center 2 grommets) may need to be removed to get the probes inserted. Make sure that the gasket present on each column stays on either the probe or in the block. Push the probes to bottom of each column and slightly tighten the black caps on the grommets. 4. Start pump and raise each probe to release pressure and get the associated column to fill. Once it is full, tighten the black cap on the grommets and move to the next probe (moving from inlet to outlet). If the columns are not filling, cover the end of the outlet discharge tubing and tighten the grommets as each column fills. No air bubbles should be present in the columns. If an air bubble is present loosen the grommet, raise the probe, wait for the bubble to disperse and lower the probe and retighten the grommets. Adjust flow using pump controls so that water is not spurting out of block. 5. The pump speed may need to be adjusted during purging as the reduction of head may require adjustment of flow through the Geotech Flowblock.

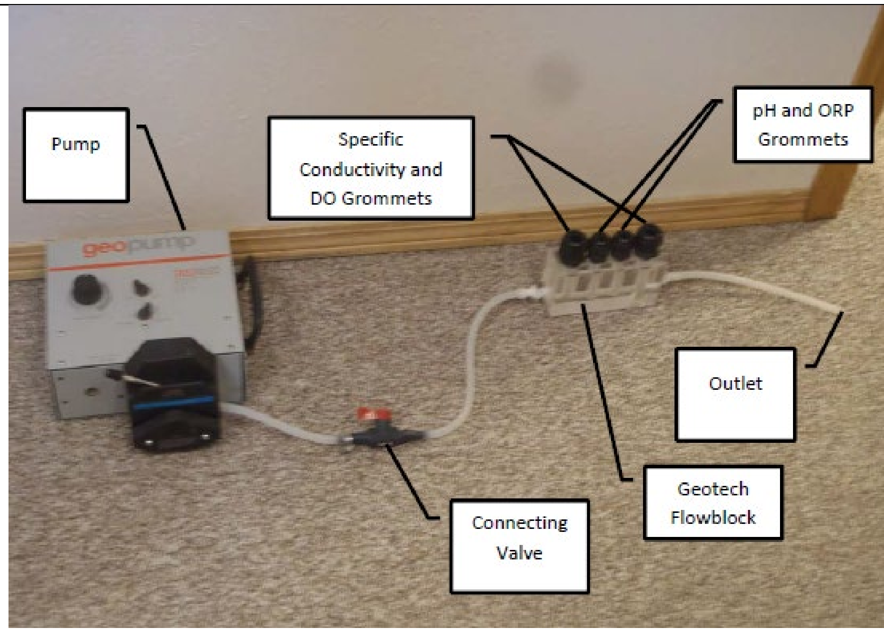
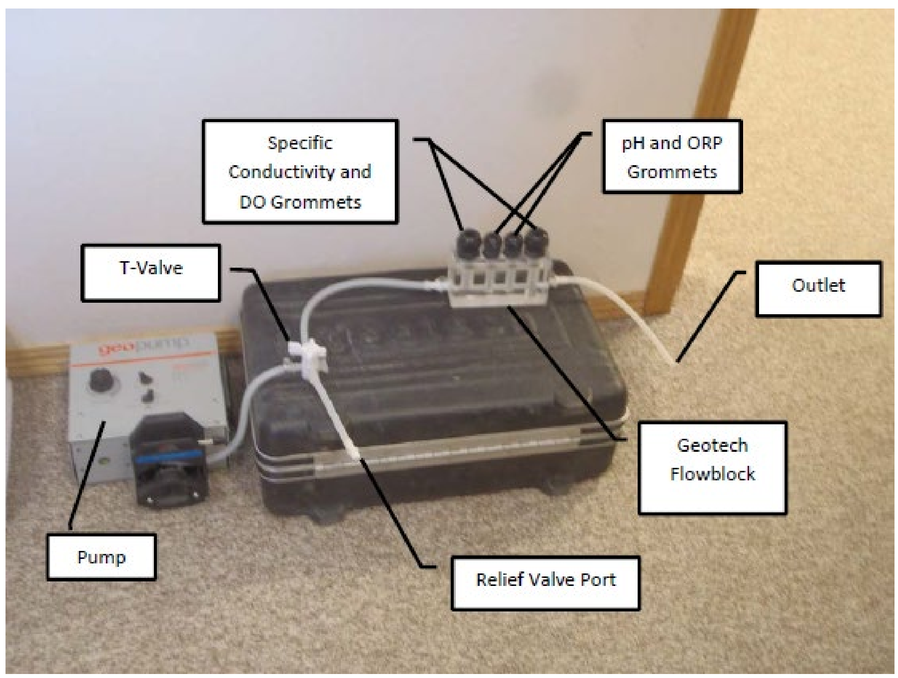


Figure 1. Geotech Flowblock

1. (Option 2) Set up Geotech Flowblock with relief valve port.	**Note: The relief valve port will be used if flow is greater than the Geotech Flowblock can handle and to collect turbidity samples for field measurement.** The Option 2 set up is shown in Figure 2 below. This set up should be used for pumping situations where flow cannot be adjusted low enough that all water can flow through the Geotech Flowblock. 1. Cut one piece of silicon tubing to connect the relief valve to the Geotech Flowblock. Use a hose clamp and attach tubing to the outlet directly across from the input on the relief valve. Using a hose clamp attach the other end of the tubing to the Geotech Flowblock. 2. Attach pump tubing to the inlet on the relief valve with a hose clamp. 3. Cut (2) 18-inch pieces of silicon tubing to handle discharge. 4. Attach one piece of this tubing to the other outlet on the relief valve. This will provide a way to discharge water that cannot flow through the Geotech Flowblock. Laboratory samples will not be collected from the relief valve, however water for field turbidity measurements will be collected from this valve. 5. The second piece of silicon tubing will be attached to the outlet side of the Geotech Flowblock. This silicon tubing needs to be long enough to discharge to the bucket or container that is being used to measure volume.

	6. Insert probes in the appropriate grommets in the Geotech Flowblock as depicted on Figure 2. Loosen the grommet to insert a probe. The black cap on the pH and ORP columns (the center 2 grommets) may need to be removed to get the probes inserted. Make sure that the gasket present on each column stays on either the probe or in the block. Push the probes to bottom of each column and slightly tighten the black caps on the grommets. 7. Start pump and raise each probe to release pressure and get the associated column to fill. Once it is full, tighten the black cap on the grommets and move to the next probe (moving from inlet to outlet). If the columns are not filling, cover the end of the outlet discharge tubing and tighten the grommets as each column fills. No air bubbles should be present in the columns. If an air bubble is present loosen the grommet, raise the probe, wait for the bubble to disperse and lower the probe and retighten the grommets. Adjust flow using pump controls and the relief valve so that water is not spurting out of block. 8. The pump and or relief valve port may need to be adjusted during purging, as the reduction of head may require the adjustment of flow through the Geotech Flowblock.  Figure 2. Geotech Flowblock with Relief Valve Port
2. Monitor and record field parameters and depth to	Adjust pumping rate as needed to maintain a minimal drawdown of <0.1 m (<4 inches). Time, flowrate and drawdown should be recorded in the logbook or on field data sheets. During well purging, monitor field parameters including pH, conductivity, and

water level measurements.	temperature. The SAP or work plan may indicate other field parameters that need to be monitored, such as ORP (eH), DO, and turbidity. As outlined in the 2018 Groundwater Sampling Guidance from the Montana Department of Environmental Quality – Contaminated Site Cleanup Bureau, water quality parameters will be considered stable when three consecutive readings (generally 2-5 minutes apart) are as follows: a. Temperature range is no more than +/- 1 degree Celsius (°C); b. pH varies by no more than 0.1 pH units; c. Specific conductivity readings are within 3% of the average; d. ORP varies by no more than 10 mV units; e. DO readings are within 10% of the average; and f. Turbidity readings are within 10% of the average. Field parameters should be recorded in the logbook or on field data sheets.
3. Collect samples.	Purge until water quality parameters stabilize. Once these conditions occur, sampling can commence by following SOP-SA-02 Sample Preservation and Containerization for Aqueous Samples. Cut the tubing just above the Connector Valve or Relief Valve and collect the samples directly from the tubing. In general, volatile organic compound (VOC) samples should not be collected when using a peristaltic pump. If VOC analysis is required, collect the VOC samples first by filling pre-preserved sample containers. Fill the sample containers by allowing pump discharge to flow gently down the side of the bottle with minimal entry turbulence. Double check for bubbles as this method tends to produce them. Cap each bottle as filled. To check for air bubbles: turn the VOC bottle upside down, tap lightly, turn right side up, see if any bubbles float to the top. If you see a bubble, remove lid, add additional water, and reseal. If a filtered sample is required, an in-line high capacity (0.45 µm) should be inserted into the discharge end of the tubing after the other sample containers are filled. Fill the sample bottle and preserve immediately; cap the bottle.
4. Label, store, and ship samples.	Label the sample bottle as appropriate and place in a cooler. Ship with other samples in accordance with SOP-SA-01 Soil and Water Sample Packaging and Shipping.
5. Dispose of used tubing.	Tubing used in the well sampling will be disposed of in accordance with SOP-DE-03 Investigation Derived Waste Handling.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated water.	Sites.	Inadvertent exposure to contaminated water could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves and safety glasses when taking field measurements, collecting, and handling samples.
	Potential contact with field parameter buffer solutions.	Equipment calibration.	Inadvertent exposure to field parameter buffer solutions could lead to adverse health effects (e.g., irritation of eye, skin, and/or respiratory tract).	Personnel will practice proper personal hygiene – wash hands prior to eating and after calibrating equipment. Employees will wear nitrile gloves and safety glasses when handling field parameter buffer solutions.
	Preservatives (HCL, HNO_3, H_2SO_4, NaOH and $Na_2S_2O_3$).	In bottles or added to bottles through sampling process.	Inadvertent exposure to preservatives could lead to adverse health effects.	Safety Data Sheets for each preservative chemical are available to all employees on the Pioneer company web site. Personnel will wear nitrile gloves and safety glasses when adding preservatives to samples bottles. Refer to the Chemical Flushing Guidelines available inside vehicle's first aid kit for first-aid procedures in case of contact with preservatives.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Bending, squatting, and kneeling.	During measurements.	Bending, squatting, and kneeling during	Employees should stretch prior to starting work and they will take breaks when necessary.

			field parameter measurements could result in muscle/back strains or other injuries.	
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Hypothermia/ frostbite.	Sites where air temperature is 35.6°F (2°C) or less.	Workers who become immersed in water or whose clothing becomes wet may be exposed to hypothermia and/or frostbite.	Employees will change clothing if it becomes wet. When applicable, employees will wear waders to prevent clothing from getting wet.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.

RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Pinch points and scrapes.	Well caps.	Personal injury could result from fingers getting pinched when opening/closing well caps.	Employees will wear work gloves when opening/closing well caps.
	Scrapes.	Attaching hose clamps.	Personal injury could result when attaching hose clamps with a screwdriver resulting in hand scrapes.	Personnel will use a nut driver, if available. Personnel will be cautious when attaching hose clamps and will wear work gloves.
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.

			effects and/or property damage.	
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, nitrile gloves, and work gloves.
APPLICABLE SDS	HCL; HNO_3; H_2SO_4; NaOH; $Na_2S_2O_3$; ORP; electrode storage solution; specific conductivity solution; pH and ORP electrode cleaner solution; pH 4, pH 7, and pH 10 buffer solutions. Additional Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
DRAWINGS	Map with site location and sample locations.
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-GW-02 Sampling with A Bailer SOP-GW-10 Purging And Sampling with A 12-Volt Submersible Pump SOP-GW-10A Purging And Sampling with A Low Flow Submersible Pump SOP-GW-10B Purging And Sampling with Grunfoss Redi-Flow Submersible Pump SOP-GW-10C Purging And Sampling with A Peristaltic Pump SOP-GW-13 Sampling Groundwater From A Tap SOP-WFM-01 Field Measurement of pH In Water SOP-WFM-02 Field Measurement of Oxygen Reduction Potential in Water SOP-WFM-03 Field Measurement of Specific Conductance SOP-WFM-04 Field Measurement of Water Temperature SOP-WFM-07 Field Measurement of Dissolved Oxygen SOP-SA-02 Sample Preservation and Containerization for Aqueous Samples SOP-SA-01 Soil and Water Sample Packaging and Shipping SOP-DE-03 Investigation Derived Waste Handling

TOOLS	Geotech Flowblock, sample bottles, sample preservatives, water quality meters, spare batteries for the field measurement meters, ORP, electrode storage, specific conductivity, pH and ORP electrode cleaner, pH 4, pH 7, and pH 10 buffer solutions, de-ionized water, 5-gallon buckets, electronic depth to water level indicator, pump, stop watch, beaker, cooler, ice, purge containers and field logbook/field data sheets.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE

By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.

SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang (signature) **Julie Flammang**	**05/22/2015**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman (signature) **Tara Schleeman**	**05/22/2015**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for using a pressure transducer datalogger for continuous groundwater level measurements.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried out under this Standard Operating Procedure (SOP) will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (OM&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Installation	

1. Program transducer.	It is recommended that transducers are programmed in the office rather than in the field to make sure everything is accurate (refer to manual for step-by-step instructions). The following information is needed when programming each transducer:
	
	• Project ID.
	• Location.
	• Level – Units in feet.
	  o Offset – Set to 0.0 feet.
	  o Altitude – Set to 0.0 feet unless site topography varies over 1,000 feet in elevation (e.g., one transducer located in a valley while another transducer is located at the top of a hill).
	  o Density – 1.0 kg/L.
	• Temperature – Units in degrees Celsius.
	• Standard Conductivity – Units in microsiemens per centimeter (µS/cm).
	• Datalogger Memory Mode – Set to slate mode.
	• Verification that the transducers and programming instrument (e.g., Solinst Leveloader™) are using the most current software/firmware.
	
	There are different models of transducers that are currently being used. Each model may not record all of the parameters listed above.

2. Determine the site-specific water column (static water level and total	Establish well specifics to determine water column (e.g., well log, if available) in an effort to bring enough supplies. Once in the field, verify water column information by using clean, non-contaminating equipment (e.g., an electronic depth to water level indicator [avoid indicating paste]), decontaminated per SOP-DE-02 Equipment Decontamination. Refer to SOP-GW-03 Depth to Water Level (DTW)

depth) and its variability.	Measurements, measure and record DTW in the logbook. For consistent water level readings, use the same DTW meter during each site visit.
3. Determine hanging height of transducer.	Determination of the transducer hanging depth in the well is site specific and depends on the well and the water level fluctuation in the area. The main priority is to keep the transducer submerged at all times while making sure it is off of the bottom of the well where sediments can build up over time. Determine a depth at which to install the transducer.
4. Determine set up to secure the transducer to the PVC/well casing.	There are many different ways to secure the transducer at the top of the well and to keep it in place depending on well construction and the project budget. Kevlar string or Dyneema® fiber work well to hang the transducer at the desired depth. Neither will stretch much after installation. It is imperative that the transducer is unable to shift/slide/slip/etc. from its original hanging position after it is attached to the polyvinyl chloride (PVC) or well casing. Again, this is site specific and should be verified with the Project Manager. If direct read cables are used, they must be properly secured to assure the transducer hanging height does not change and should have a backup hanging system (e.g., Kevlar string) in the event the cable is cut. Never attach the transducer to anything removable (e.g., well cap) unless there are no other means to attach the device. The easiest and most effective method for securing the transducer at a specified depth in the well is to install an eye-bolt or hook into the outer well casing (hook or eye should be to the inside of the casing). A large hose clamp over the inner PVC casing could also be used to secure the string. For security reasons, try to attach the string or direct read cable so that it is entirely contained within the outer well casing. Don a new pair of nitrile or latex gloves. Tie the string/fiber to the transducer. Measure the appropriate amount of string/fiber required to install the transducer at the determined depth plus a small amount to attach the string/fiber to the casing. While measuring the string/fiber, field personnel should wear latex or nitrile gloves and make sure the string/fiber does not contact the ground. Cut the string/fiber. If using a direct read cable, screw the direct read cable to the transducer. Care should be taken to only twist the connectors and not the cable. Measure out the appropriate amount of cable to install the transducer at the pre-determined depth, coil and secure any leftover cable with a zip tie. Secure the string/fiber to the hook, eye bolt or hose clamp at the top of the casing.
5. Start the transducer.	If needed, remove the cap from the transducer and/or direct read cable. Using special care to only twist the connectors and not the cables, connect to the transducer or direct read cable using either the Leveloader™ or a field laptop computer (pre-loaded with the most recent version of transducer specific software) using a PC connector cable. An optical reader can also be used in conjunction with the Leveloader™ or a field laptop computer to program the transducer. Check, and if needed, set the present date and time. Daylight savings time should never be accounted for and the transducer's time should always be set to standard. The time should also be synced to an exact time (e.g., cell phone). Set the transducer for a future start time, never start at the current time. Double check the interval time set

	in the initial program setup (e.g., a reading every four hours, readings at 15-minute intervals, etc.). Set the future start time so that one of the interval loggings occurs at 12:00 AM. If transducers are to be installed in more than one well, set each transducer to start recording at the same future start time and the same logging interval. Once the programming is complete, close out of the program, and disconnect the transducer from the Leveloader™ or field laptop computer. Put the cap back on the transducer and/or the direct read cable, being careful to only twist the cap and not the cables.
6. Deploy the transducer.	Confirm that the string/fiber is firmly attached to both the transducer and the top of the well. Lower the transducer into the well slowly to the predetermined depth. Reconfirm that the string/fiber are firmly attached to the top of the well. Replace the well cap. Close and lock the well casing.
7. Barologger installation.	A Barologger will need to be installed to log barometric pressure. Barologger readings can be used to compensate any transducer data from wells that are within 1,000 feet of elevation and within a 20-mile radius. If possible, choose a central location that allows all transducers being installed to fall within these criteria. The Barologger can be installed within a well, above the high water level, at the location or in a nearby building. Additional Barologgers will need to be installed if any transducers fall outside of these parameters. Following the manufactures operating manual, set the Barologger to start at the same time as the transducers and record at the same time interval. The following information should also be programmed into the Barologger: • Project ID. • Location. • Level – Units in kPa. • Temperature – Units in degrees Celsius. Installation of the Barologger is similar to installing a transducer. After verifying the high water level to avoid the Barologger coming into contact with water, cut a piece of Kevlar string or Dyneema® fiber to hang the Barologger at the desired height within the well casing. In an ideal situation the Barologger will be installed between the inner well casing (PVC) and the outer metal protective casing. The length of the string should allow the Barologger to hang down below the top of the inner well casing so it won't be disturbed during monitoring/sampling activities, but short enough that it doesn't touch the ground. The Barologger can also be installed within the inner well casing if there is not enough space between the inner and outer casing. The Barologger will need to be removed during sampling and monitoring activities. Do not remove it when a logging interval is near as it could impact the specific reading. The Barologger can be hung from the same eye-bolt, hook or hose clamp as the transducer, or hung using its own dedicated setup.

Downloading	
1. Measure the water level in the well.	The static water level must be measured prior to downloading the transducer. This insures the water column height was not compromised (e.g., pulling the transducer causing the water level to drop). Using clean, non-contaminating equipment (e.g., an electronic depth to water level indicator [avoid indicating paste]), decontaminated per SOP-DE-02 Equipment Decontamination, determine the water level in the well. Refer to SOP-GW-03 Depth to Water Level Measurements for instructions and record in the logbook. To ensure consistent water level readings an effort should be made to use the same DTW meter during each site visit. Rinse probe with DI water between locations.
2. Download data.	If a direct read cable was used in the well, connect to the transducer using either the Leveloader™ or a PC interface cable and the field laptop. If a direct read cable was not installed, don a pair of nitrile or latex gloves and remove the transducer from the well, noting the time on the field data sheet or in the field logbook. Place a piece of new plastic on the ground and place string on it as the transducer is removed from the well, alternately have field personnel collect the string so that it does not touch the ground during removal. Remove the cap from the transducer and/or direct read cable and place it in the optical reader or attach the PC interface cable (twist the connector, not the cable). Care should be taken not to misplace the cap removed from the transducer or direct read cable. The field laptop computer should have the most current software/firmware. Using either the Leveloader™ or the field laptop computer download the data (refer to manual for step-by-step instructions). If a direct read cable is installed, also record the real-time measurements in the logbook.
3. Start the transducer.	Set the transducer to a future start at a specific time (e.g. every four hours, 15-minute intervals, etc.) with one of the intervals logging at 12:00 AM. Never start at the current time.
4. Reinstall the transducer.	When downloading is complete, put the cap back on the direct read cable or transducer taking care not to twist the cable only the connectors. Replace the direct read cable inside the well casing or reinstall the transducer into the well as discussed in Step 6 above. Once the transducer is back in place note the time in the logbook or on the field data sheet. Close and lock the well casing.
Maintenance	
1. Battery Life	Each transducer has a 10-year battery life (based on one reading/min). Prior to transducer deployment, it is important to note the age of the instrument as well as monitor the battery level during each field visit. When reaching the end of the battery life, readings may begin to drift from the actual water levels. Periodic readings from the transducer should be compared to the manual water levels to help indicate the accuracy of the transducer and if it should be replaced.
2. Calibration	The Solinst® LTC Levelogger Junior F30/M10 transducer should be calibrated for conductivity every six months (refer to manual for step-by-step instructions).

HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated water.	Sites.	Inadvertent exposure to contaminated water could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves and safety glasses during monitoring activities.
	Exposure to 1413 µs/cm calibration standard solution.	Equipment calibration.	The calibration standard solution may cause irritation of eyes and skin.	Personnel will practice proper personal hygiene – wash hands prior to eating and after calibrating equipment. Employees will wear nitrile gloves and safety glasses when handling the calibration standard solution.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Bending, squatting, and kneeling.	During monitoring activities.	Bending, squatting, and kneeling during monitoring activities could result in muscle/back strains or other injuries.	Employees should stretch prior to starting work and they will take breaks when necessary.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold	Training on signs and symptoms of cold/heat stress is required. Personnel will wear

			burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Pinch points.	Well caps.	Personal injury could result from fingers getting pinched when opening/closing well caps.	Employees will wear work gloves when opening/closing well caps. Watch hand placement when opening/closing well caps.
PRESSURE	Not applicable.			
THERMAL	Not applicable.			

HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
	Interaction with public.	Sites.	Public can enter the work area and interfere with work activities.	Personnel will stop work, if public enters the work area. Work will resume once public has left the area.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, nitrile gloves, and work gloves.
APPLICABLE SDS	Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants. Standard conductivity calibration solution (1413 µS/cm).
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	Map with site location and sample locations.
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-DE-02 Equipment Decontamination and SOP-GW-03 Depth to Water Level Measurements.
TOOLS	Electronic depth to water level indicator, appropriate instrument connecting cables, eye bolt, string, piece of plastic sheeting, keys to locks, field laptop/Leveloader, field logbook, DI water, and standard conductivity calibration solution (1413 µS/cm).
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**06/05/2015**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**06/05/2015**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for sampling soils from a liner from a Geoprobe® 66 DT Series.
SCOPE	This practice is for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work performed under this Standard Operating Procedure (SOP) will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Preparation	
1. Check of liner materials.	Make sure that the liner used to contain the soils in the Geoprobe® probe rods is made of material compatible with the contaminants being analyzed.
2. Set up the sample and staging area.	Cover a folding table with plastic. The table should be at least as long as the liners to be sampled. A tailgate covered with plastic can also be used. If the only available surface is the ground, place several layers of plastic a couple of feet longer than the liners. Secure the layers of plastic so they do not blow around during sampling. In addition to the sampling area, a staging area for unsampled core needs to be designated. This area should also be covered with plastic to keep the liners clean before placement on the sampling area.
3. Mark the liners.	As the Geoprobe® operator removes core (liners) from the probe rods, mark with a waterproof marker the “top” and “bottom” of the liner as well as the interval that the liner represents. Cap the liner ends with vinyl or Teflon end caps. Move core to the staging area.
4. Record information provided by the operator.	If possible, confer with the Geoprobe® operator for any issues associated with probing each interval. For example, was there a loss of material due to a rock blocking the tube, was there a section that drilled extremely easy and may indicate material that was easily compressed or perhaps the presence of a void, was there a problem with recovery due to saturated soils, etc. Record any information provided by the operator in the field logbook or on the field data sheet. This information can be referenced when logging the core.

Sampling of Soils for Inorganic Constituents	
1. Cut the plastic liner lengthwise.	The Geoprobe® operator and/or helper will cut the top portion of the plastic liner lengthwise. The opening along the top should be at least 2 inches wide. Care should be taken when handling and working around the cut liner as the cut edges are sharp.
2. Place the liner on the prepared sampling surface.	Place the liner on the prepared sampling surface and take the cut portion off. The portion of the liner marked "top" should be placed in the same direction on the sample surface each time. Place the index cards marked "top" and "bottom" on the appropriate ends of the liner. Place an extended tape measure adjacent to the liner. Index cards marked with appropriate intervals can also be used. Take a picture of the exposed soils. Do not move the tape measure or core after the photo. If the core does not need to be photographed, and it is **NOT** being analyzed for organics, mark the liner at the appropriate foot intervals with a Sharpie®.
3. Measure and record material in the core.	Measure and record the number of inches of material in the core, this will be recorded in the field logbook or on the field data sheet as length recovered (e.g., 36 inches from a 4-foot push or 18 inches from a 2-foot push). This measurement should not include any material that appears to have sluffed from an upper interval (i.e., leaves or topsoil present at the top of deeper subsurface cores). Record this information in the field logbook or on a field data sheet as specified in the Sampling and Analysis Plan (SAP). Evaluate the recovery of the core based on the operator's comments. Determine the amount of material that represents one foot of the profile. For example, 36 inches of recovered soil from a 4-foot probe may indicate 9 inches were recovered per foot. An alternate method for determining interval depth is to assume that the 36 inches represented 36 inches from either the top or the bottom of the probed interval and that there was no recovery for 4 inches of the interval. These are not precise ways to determine how far below ground surface a soil horizon lies, as different soil types and moisture levels will compress or expand differently when pushed with the probe. There is no way to determine where or whether compression/expansion in the soil profile occurred. Chose one of these methods and be consistent throughout the project. Another scenario that may occur would be if the operator indicates that an obstruction was encountered that may have blocked soils from entering the liner at the 2-foot interval in a probe. If there is only 24 inches of soil and a large rock present in the liner, this may represent only the 0-2 foot interval in that core and should be recorded that way in the field logbook or on the field data sheet along with the operator's comment.
4. Log the core.	Examine and log the material in the liner. Keep in mind that due to smearing of soils during probing, a coating of wet or fine material may be present on the outside of the soil core. Using a gloved finger, make indentations down the core noting differences in texture, color, staining or odor. Record this information in the field logbook or on the field data sheet. To avoid cross contamination, change fingers as you make indentations.

5. Determine sample intervals.	Determine sample intervals as described in the SAP or Work Plan (WP). If the material is **NOT** being sampled for organics, the sample intervals can be marked on the liner using a Sharpie®. An alternate method would be to separate the sample intervals, so that a gap is present between the intervals. This makes it easier to get the appropriate intervals in the sample when the tape measure is removed. Record the sample interval information in the field logbook or on the field data sheet.
6. Collect soil samples.	Slide the tube to the end of the table or sampling surface. Using a new plastic disposable scoop, slide the appropriate marked sample interval into a new disposable foil pan or stainless-steel bowl. Alternately, a gloved finger, or a clean screwdriver can be used. The screwdriver is particularly helpful if portions of the soil are hardpacked or compressed. Mix the material in the pan/bowl thoroughly and remove rock and debris > 0.5 inches. If more material is required to fill sample containers, a second hole can be probed immediately adjacent to the first and material from the 2^{nd} liner from the same interval can be added to the pan/bowl and mixed. Repeat this process for all intervals to be sampled. Be aware of the potential for cross contamination and if needed change gloves or scoops between intervals.
7. Put samples in containers.	Prepare the appropriate sample containers with a label as described in the SAP or the Quality Assurance Project Plan. Fill the sample containers with homogenized material from the pan/bowl using the associated sampling tool. After sampling, place the samples in a cooler with ice until they can be transported to the laboratory for analysis as described in SOP-SA-01 Soil and Water Sample Packaging and Shipping.
Sampling of Soils for Organic Constituents	
1. Place caps on the end of the core tubes.	Ensure that the Geoprobe® operator and/or helper places caps on the end of the core tubes immediately after removing the liner from the probe rods. **Do not** have the operator/helper cut the tubes until just before core will be sampled.
2. Prepare the sample container.	Based on information provided in the SAP/WP, prepare the appropriate sample containers with a label. This is particularly important if sampling for Volatile Organic Compounds (VOCs).
3. Cut the plastic liner lengthwise.	Have the Geoprobe® operator and/or helper cut the top portion of the plastic liner lengthwise. The opening should be at least 2 inches wide. **DO NOT REMOVE THE CUT PORTION OF THE LINER**. Care should be taken when handling and working around the cut liner as the cut edges are sharp.
4. Place the liner on the prepared sampling surface.	Place the liner on the prepared sampling surface. **Do not** remove the cut portion. Place the portion of the liner marked “top” in the same direction on the sample surface each time. Place the index cards marked “top” and “bottom” on the appropriate ends of the liner. Place an extended tape measure adjacent to the liner. Index cards marked with appropriate intervals can also be used.

5. Measure and record material in the core.	**Prior** to removing the cut portion of the liner, measure and record the number of inches of material in the core. See discussion in Step 3 of Sampling of Soils for Inorganic Constituents to determine how depth of sample intervals will be determined.
6. Take a picture of the exposed soils.	Remove the cut portion of the liner. Quickly take a picture of the exposed soils. Do not move the tape measure or core after the photo.
7. Conduct PID readings if required.	**VOC and Volatile Petroleum Hydrocarbon (VPH) samples need to be collected as quickly as possible after opening the tube.** If specified in the SAP/WP, use a photoionization detector (PID) to take readings of the length of the core. Move slowly and if volatiles are detected, return to those areas and record the highest number measured as well as the amount of core involved.
8. Log the core.	If sampling for VOCs, quickly examine the material in the liner. Keep in mind that due to smearing of soils during probing, a coating of wet or fine material may be present on the outside of the soil core. Using a gloved finger, make indentations down the core. Quickly note differences in texture, color, staining or odor. Once the VOC/VPH samples have been collected, do a more thorough examination and record the information in the field logbook or on the field data sheet. To avoid cross contamination, change fingers as you make indentations.
9. Prepare and collect soil samples for VOCs/VPH.	Determine sample intervals for VOCs/VPH as described in the SAP/WP. Sample intervals may be assigned in the SAP or based on PID readings or the presence of odor or staining. Collect the VOC/VPH samples directly from the tube using a plastic disposable scoop, gloved hand or screwdriver. The tape measure can be used to identify the intervals, or small gaps can be made between sample areas so that once the soil is moved the appropriate unit can be identified. Place the soil directly into the sample container and fill the jar to the top allowing no head space (or as the laboratory directs). Be aware of the potential for cross contamination and if needed change gloves or scoops between intervals. Immediately place the sample containers in a cooler with ice until they can be transported to the laboratory for analysis as described in SOP-SA-01 Soil and Water Sample Packaging and Shipping.
10. Prepare soil samples for additional analytes.	Sample intervals that are not going to be submitted for VOC/VPH can be collected after VOC/VPH sampling is completed. Prior to completing the sampling, finish logging the core and record all the information in the field logbook or on the field data sheet. Determine the intervals to be sampled for additional analytes. Separate the sample intervals, so that a gap is present between the intervals. This makes it easier to get the appropriate sections into the sample when the tape measure is removed. Record the sample interval information in the field logbook or on the field data sheet.
11. Collect soil samples.	Slide the tube to the end of the table or sampling surface. Using a new plastic disposable scoop, slide the appropriate marked sample interval into a new disposable foil pan or stainless-steel bowl. Alternately, a gloved finger, or a clean screwdriver can be used. The screwdriver is particularly helpful if portions of the soil are hardpacked or

	compressed. Mix the material in the pan/bowl thoroughly and remove rock and debris > 0.5 inches. If more material is required to fill sample containers, a second hole can be probed immediately adjacent to the first and material from the 2nd liner from the same interval can be added to the pan/bowl and mixed. Fill the sample containers with the homogenized materials from the pan/bowl using the associated sampling tool. Repeat this process for all intervals to be sampled. Be aware of the potential for cross contamination and if needed change gloves or scoops between intervals.
12. Label the sample containers and store them in a cooler.	Make sure all sample containers are labeled correctly. These sample containers should also be placed in a cooler with ice for transport to the laboratory as described in SOP-SA-01 Soil and Water Sample Packaging and Shipping.
Decontamination of Equipment following both Organic or Inorganic Sampling	
1. Clean the plastic placed over the sample area.	Between each core, sweep or wipe down the plastic using deionized water (DI) wetted paper towels. If a particularly muddy core was sampled, the plastic may need to be replaced or a new piece placed over the sample area.
2. Decontaminate equipment.	Decontaminate the cutting tool, tape measure, and screwdrivers using paper towels wetted with a Liquinox/water mixture and the DI water spray bottle to rinse. If sampling for organics, use paper towels wetted with methanol for a final wipe down. If stainless-steel bowls, spoons, and trowels were used, please follow SOP-DE-02 Equipment Decontamination for instructions.

HSSE CONSIDERATIONS

This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	*HAZARDS*	*WHERE*	*HOW, WHEN, RESULT*	*CONTROLS*
CHEMICAL	Potential contact with contaminated soils and groundwater.	Sites.	Inadvertent exposure to contaminated soils and groundwater could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Personnel will wear nitrile gloves and safety glasses when contact with soils and groundwater is possible. Sampling will be conducted outdoors or in a trailer with open doors.
	Exposure to hydraulic fluids.	Geoprobe® operations.	Exposure to hydraulic fluids could occur while working around the Geoprobe® due to equipment malfunction/ failure resulting in personal injuries.	The operator will inspect the Geoprobe® and document inspections daily before starting work. The operator will also replace/repair all faulty equipment before starting work. When inspecting equipment, personnel will wear work gloves to prevent possible exposures to hydraulic fluids. Non-essential personnel will maintain a 20-foot buffer zone round the Geoprobe®.
	Liquinox.	Equipment decontamination.	Personnel could be exposed to Liquinox via ingestion and skin/eye contact when decontaminating the equipment resulting in adverse health effects.	Personnel will wear nitrile gloves and eye protection when decontaminating the equipment.

CHEMICAL	Methanol.	Equipment decontamination.	Personnel could be exposed to methanol via skin/eye contact and ingestion/ inhalation when decontaminating equipment. Exposure could cause irritation of skin/eye. Adverse health effects can also result, if methanol is ingested and/or inhaled. Direct contact with methanol during winter months can result in skin discomfort due to rapid evaporative cooling.	Personnel will prevent skin/eye contact with methanol and they will wear nitrile gloves and safety glasses when handling methanol. Personnel will use methanol in well-ventilated areas. Personnel will also practice proper personal hygiene – wash hands prior to eating/drinking, after decontamination procedures, and when leaving the site. During winter months, personnel will wear a pair of liner gloves underneath nitrile gloves.
NOISE	Elevated noise levels.	Geoprobe® operations.	Personnel could be exposed to elevated noise levels when working near the Geoprobe® operations resulting in hearing damage.	Personnel will wear hearing protection (e.g., ear plugs) when working near the Geoprobe®. Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe®, when possible. Hearing protection will be administered and used in accordance with the policies and procedures outlined in the Pioneer Corporate HASP.
ELECTRICAL	Not applicable.			

BODY MECHANICS	Bending, squatting, and kneeling.	During fieldwork activities.	Bending, squatting, and kneeling during fieldwork activities could result in muscle/back strains or other injuries.	Personnel should stretch prior to starting work and they will take breaks when necessary.
	Improper lifting/handling of heavy items.	During field work activities.	Back injuries and muscle/back strains could result when using improper techniques to lift/carry heavy coolers and containers with core pieces.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two workers will lift/handle heavy items as needed.
	Flying debris.	Geoprobe® operations.	Eye injuries could result from flying debris when working around Geoprobe® operations.	Personnel will wear safety glasses when working around Geoprobe® operations. Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe® when possible.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces, and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Personnel will wear work boots with good traction and ankle support. They will plan their path, walk cautiously, and keep work areas as dry as possible. Personnel will wear muck boots as necessary.
WEATHER	Cold/heat stress.	Outdoor sites.	Exposure to cold climates may result in cold burns, frostbite, and hypothermia. Exposure to high temperatures may result in heat cramps, heat	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors (e.g., layers and loose clothing). Personnel will remain hydrated and will have sufficient caloric intakes during the day. Personnel will

WEATHER			exhaustion, or heat stroke.	follow procedures outlined in the applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Personnel will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors sites.	Personnel could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Personnel will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Personnel should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Outdoors.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First aid kits will be available in company vehicles. Personnel with allergies will notify their supervisor.
MECHANICAL	Sharp edges and cutting tool.	Plastic liners and cutting tool.	Personal injury could result while cutting the plastic liners open to collect the soil samples. The plastic liners could also have sharp edges after they are cut. Cuts and scrapes could result from direct contact with sharp edges.	Personnel will use a specialized tool to cut the plastic liners and they will wear work gloves to prevent hand injuries. Personnel will use a tray and clamp to hold the plastic liner in place and keep it from moving around. Personnel will be aware of hand placement to prevent exposure to sharp edges and cutting tool.

PRESSURE	Pressurized hydraulic hoses.	Geoprobe®.	Hydraulic hoses could burst/rupture resulting in inadvertent contact with hydraulic fluid or personal injury due to being struck by hoses.	The operator will inspect the Geoprobe® and document inspections daily before starting work. The operator will also replace/repair all faulty equipment before starting work. When inspecting equipment, personnel will wear work gloves to prevent possible exposures to hydraulic fluids. Non-essential personnel will maintain a 20-foot buffer zone round the Geoprobe®.
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained personnel.	Sites.	Inexperienced personnel and improper training could cause incidents resulting in adverse health effects and/or property damage.	Personnel will be properly trained in the procedure described above and other applicable procedures. Personnel will follow the stop work policy, if there are any issues.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	**Personal Protective Equipment** (PPE): Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, nitrile gloves, and leather gloves.
APPLICABLE SDSs	**Safety Data Sheets** (SDSs) will be maintained based on the site characterization and contaminants.
REQUIRED PERMITS/ FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
DRAWINGS	Map with site location and sample locations.
RELATED SOPs/ PROCEDURES /WORK PLANS	SOP-SA-01 Soil and Water Sample Packaging and Shipping and SOP-DE-02 Equipment Decontamination – Inorganic Contaminants.
TOOLS	Sample area – plastic sheeting, folding table (1 or 2), tape to secure plastic, tape measure, index cards to indicate top and bottom, camera, PID (if required), plastic disposable scoops or SS spoons or spatulas, screwdrivers, DI water spray bottle, Liquinox/water spray bottle, methanol, paper towels, foil disposable pans or stainless-steel bowls, sample containers, dual blade cutter, and liner holders.
FORMS/ CHECKLIST	Field logbook and field data sheets.

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang (signature) **Julie Flammang**	**05/30/2018**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman (signature) **Tara Schleeman**	**05/30/2018**

PURPOSE	To provide standard instructions for soil and water sample packaging and shipping.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
1. Preserve the samples.	Water samples will be preserved, if required, according to SOP-SA-02 Sample Preservation and Containerization for Aqueous Samples, and SOP-SA-02B Sample Preservation and Containerization for Aqueous Samples for VOAs.
2. Place the sample containers in Ziploc bags.	Based on the analytes requested (e.g., low level mercury, low level chromium, etc.), it may be necessary to place each filled sample container in separate Ziploc bags to prevent cross contamination, keep the container clean, dry, and isolated, and protect the sample label. In most cases, all sample containers collected from a specific sample location are placed in a large Ziploc bag and shipped together.
3. Package the samples.	Place samples in a cooler, which has been previously lined with a plastic bag. Surround the samples with non-contaminating packaging materials to reduce movement and absorb any leakage. Double bag the ice and place it in the cooler. Seal the plastic bag in the cooler to contain the samples, packing material, and ice.
4. Review and sign COC forms.	The Field Team Leader or their designated representative will double check the chain-of-custody (COC) forms to assure those samples recorded on the COC forms are in the cooler. The Field Team Leader or the designated representative will then sign the chain-of-custody form to relinquish custody. One copy of the signed COC form will remain with the Field Team Leader. Make a photocopy of the completed forms, if there are no carbon copies available.
5. Tape paper work to cooler.	Place paper work in a sealed Ziploc bag and tape it to the inside of the cooler lid.
6. Bag samples for separate analytical batches.	If the shipping cooler contains more samples than can be analyzed in one analytical batch, the laboratory may request that the samples in the cooler be bagged for separate analytical batches. This may be necessary so that the appropriate Quality Control/Quality Assurance samples are included in each analytical batch. In this case, fill out separate COC forms for each batch and include the forms in the

	appropriate plastic bags. Place the COC forms for each batch in a sealed Ziploc bag. The COC forms for each batch should be placed at the top of the plastic bag so that they are clearly visible to laboratory personnel when they open the plastic bags.
7. Label the cooler.	Label the cooler with the appropriate labels to describe the content of the cooler (e.g., NOS, flammable liquids, flammable solids, this side up, fragile, etc.). Close the cooler and place the appropriate shipping labels (e.g., overnight shipping from Federal Express, UPS, or the United States Postal Service or equivalent) on the lid of the cooler.
8. Sign COC seals.	The Field Team Leader or the designated representative will sign COC seals and place the signed seals over the opening edge of the cooler.
9. Tape the cooler.	Place tape over the custody seals and around the cooler.
10. Transport the cooler.	Transport the cooler(s) to a secure storage, to the shipping agent, or directly to the laboratory. If shipping the cooler, follow established federal and state regulations depending on cooler content.
Notes	Bagging of samples and lining of coolers is not necessary, if samplers transport the samples directly to the laboratory.

HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	*HAZARDS*	*WHERE*	*HOW, WHEN, RESULT*	*CONTROLS*
CHEMICAL	Potential contact with contaminated soil and water samples.	Sites.	Inadvertent exposure to contaminated soil and water samples could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves and safety glasses when handling sample containers.
	Preservatives (HCL, HNO3, H2SO4, Zinc, Acetate, NaOH).	In bottles or added to bottles through sampling process.	Inadvertent exposure to preservatives could lead to adverse health effects.	Safety Data Sheets for each preservative chemical are available to all employees on the Pioneer company web site. Personnel will wear nitrile gloves and safety glasses when adding preservatives to samples bottles and when handling the bottles. Refer to the Chemical Flushing Guidelines available inside vehicle's first aid kit for first-aid procedures in case of contact with preservatives.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Bending, squatting, and kneeling.	During sample packaging.	Bending, squatting, and could result in muscle/back strains or other injuries.	Employees should stretch prior to starting work and they will take breaks when necessary.
	Improper lifting.	Sites.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry coolers with samples.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two workers will lift/carry the coolers, if needed.

GRAVITY	Not applicable.			
WEATHER	Not applicable.			
RADIATION	Not applicable.			
BIOLOGICAL	Not applicable.			
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Sampling site: hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves. Off site: nitrile gloves.
APPLICABLE SDS	HCL, HNO3, H2SO4, Zinc, Acetate, and NaOH. Additional Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-SA-02 Sample Preservation and Containerization for Aqueous Samples and SOP-SA-02B Sample Preservation and Containerization for Aqueous Samples for VOAs.
TOOLS	Plastic bags, Ziploc bags, non-contaminating packaging materials, tape, COC seals, ice, and cooler.
FORMS/CHECKLIST	Chain-of-custody (COC) forms.

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang (signature) **Julie Flammang**	**12/11/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman (signature) **Tara Schleeman**	**12/11/2014**

Revisions:

Revision	Description	Date

PURPOSE	The SOP covers aqueous samples being analyzed for commonly requested organic, inorganic and RADCHEM parameters. Guidance is provided on industry standard containers, preservatives, analytical methods and holding times associated with sample collection.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Notes	Most bottles come certified and preserved from the laboratory. If bottles do not contain preservatives, field personnel will add it at the time of water sample collection. If bottles are not certified, a triple rinse with the water to be sampled will be done before collecting the sample. Preservative will be added to the sample container after triple rinse and before sample collection. The following information was supplied to Pioneer from Pace Analytical Services. If another laboratory is contracted for analyzing samples, verify with the laboratory the appropriate containers, preservatives and holding time limits for the required analyses. If a different analytical method is specified in the Sampling and Analysis Plan (SAP) from those listed below verify with the contracted laboratory for sampling method, container requirements, preservative and holding time limits.
Label samples	Label samples as per SOP-SA-01 Soil and Water Sample Packaging and Shipping.

Organic Parameters in Aqueous Samples

Parameter	Method: EPA Drinking Water	Method: EPA Water	Method: EPA Waste SW-846	Container	Preservative	Max Hold Time
Aromatic and Halogenated Volatiles		601/602	8021	3 - 40mL vials	pH<2 HCl, ≤6°C, $Na_2S_2O_3$ if Cl present	14 Days (7 days for aromatics if unpreserved)
Base/Neutrals and Acids		625	8270	1L Amber Glass	≤6°C, $Na_2S_2O_3$ if Cl present	7/40 Days
Base/Neutrals, Acids & Pesticides	525.2			1L Amber Glass	pH <HCl, sodium sulfite if Cl present	14/30 Days
Diesel Range Organics			8015	1L Amber Glass	≤6°C, $Na_2S_2O_3$ if Cl present	7/40 Days
Dioxins and Furans	1613B			1L Amber Glass	≤6°C, $Na_2S_2O_3$ if Cl present	1 Year
Dioxins and Furans			8290	1L Amber Glass	≤6°C, $Na_2S_2O_3$ if Cl present	30/45 Days
Dissolved Organic Carbon			Method 5310	250 ml Amber Glass	Field Filter from an Unpreserved Sample into an pH<2 H2SO4, ≤6°C	28 days
EDB & DBCP	504.1		8011	40mL vials	≤6°C, $Na_2S_2O_3$ if Cl present	14 Days
Explosives			8330/8332	1L Amber Glass	≤6°C	7/40 Days
Gasoline Range Organics			8015	40mL vials	pH<2 HCl	14 Days
Haloacetic Acids	552.1/552.2			40mL Amber vials	NH_4Cl, ≤6°C	14/7 Days if extracts stored at ≤6°C or 14/14 Days if extracts stored at ≤-10°C
Herbicides, Chlorinated	515.1/515.3		8151	1L Amber Glass	≤6°C, $Na_2S_2O_3$ if Cl present	7/40 Days for 8151; 14/28 Days for 515.1/515.3
PCBs, Organochlorine			8082	1L Amber Glass	≤6°C; $Na_2S_2O_3$ if Cl present	1 Year/1Year
PCBs & Pesticides, Organochlorine		608		1L Amber Glass	≤6°C; $Na_2S_2O_3$ if Cl present	7/40 Days
Pesticides, Organochlorine			8081	1L Amber Glass	≤6°C, $Na_2S_2O_3$ if Cl present	7/40 Days
Pesticides, Organophosphorus			8141	1L Amber Glass	pH 5-8 with NaOH or H_2SO_4; ≤6°C, $Na_2S_2O_3$ if Cl Present	7/40 Days
Polynuclear Aromatic Hydrocarbons			8270 SIM	1L Amber Glass	≤6°C, $Na_2S_2O_3$ if Cl present	7/40 Days
Volatiles		624	8260	3 - 40mL vials	pH<2 HCl; ≤6°C	14 Days (7 Days for aromatics if unpreserved)
Volatiles (see note 1)	524.2			40mL vials (in duplicate)	pH<2 HCl, ≤6°C, $Na_2S_2O_3$ if Cl present	14 Days

[1] Method 524.2 lists ascorbic acid as the preservative when residual chlorine is suspected, unless gases or Table 7 compounds are NOT compounds of interest and then sodium thiosulfate is the preservative recommended.

Inorganic Parameters in Aqueous Samples

Parameter	Method: EPA Water	Method: Standard Methods	Method: EPA Waste SW-846	Container	Preservative	Max Hold Time
Acidity		SM2310B		Plastic/Glass	≤6°C	14 Days
Alkalinity	310.2	SM2320B		Plastic/Glass	≤6°C	14 Days
Anions by IC, including Br, Cl, F, NO2, NO3,o-Phos, SO4, bromate, chlorite, chlorate)	300.0			Plastic/Glass	≤6°C	All analytes 28 days except NO2, NO3, o-Phos (48 hours); chlorite (immediate); NO2/NO3 combo 28 days
Bacteria, Total Plate Count		SM9221D		Plastic/WK	≤6°C, $Na_2S_2O_3$	24 Hours
BOD/cBOD		SM5210B/Hach 10360		Plastic/Glass	≤6°C	48 hours
Chloride		SM4500Cl-C,E		Plastic/Glass	None	28 Days
Chlorine, Residual	330.5	SM4500Cl-D, E, G / Hach 8167		Plastic/Glass	None	15 minutes
COD	410.4	SM5220C, D / Hach 8000		Plastic/Glass	pH<2 H_2SO_4, ≤6°C	28 Days
Color		SM2120B,E		Covered Plastic, Acid Washed Amber Glass	≤6°C	24 Hours
Cyanide, Reactive			Chapter 7	Plastic/Glass	None	28 Days
Cyanide, Total and Amenable	335.4	SM4500CN-A,B,C,D,E,G,I,N	9010/9012	Plastic/Glass	pH>12 NaOH; ≤6°C ascorbic acid if Cl present	14 Days (24 hrs if sulfide present - applies to SM4500CN only)
Ferrous Iron		SM3500Fe-D		Glass	None	Immediate
Flashpoint/Ignitability			1010	Plastic/Glass	None	28 Days
Fluoride		SM4500Fl-C,D		Plastic	None	28 Days
Hardness, Total (CaCO3)	130.1	SM2340B,C		Plastic/Glass	pH<2 HNO_3	6 Months
Hexavalent Chromium	218.6	SM3500Cr-C,D	7196	Plastic/Glass	≤6°C	24 Hours, unless preserved per method, then 28 Days
Mercury	245.1/245.2		7470	Plastic/Glass	pH<2 HNO_3	28 Days
Mercury, Low Level	1631E			Fluoropolymer (Glass if Hg is only analyte being tested)	12N HCl or BrCl	48 hours for preservation or analysis; 28 days to preservation if sample oxidized in bottle; 90 days for analysis if preserved
Metals (ICP/ICPMS)	200.7/200.8		6010/6020	Plastic/Glass	pH<2 HNO_3	6 Months
Nitrogen, Ammonia	350.1	SM4500NH3		Plastic/Glass	pH<2 H_2SO_4, ≤6°C	28 Days
Nitrogen, Kjeldahl	351.2	SM4500-Norg		Plastic/Glass	pH<2 H_2SO_4, ≤6°C	28 Days
Nitrogen, Nitrate	352.1	SM4500-NO3		Plastic/Glass	≤6°C	48 Hours
Nitrogen, Nitrate & Nitrite, combined	353.2	SM4500-NO3		Plastic/Glass	pH<2 H_2SO_4, ≤6°C	28 Days
Nitrogen, Organic	351.2 / 350.1	SM4500-Norg		Calculation	pH<2 H_2SO_4, ≤6°C	28 Days
Odor		SM2150B		Glass	≤6°C	24 Hours
Oil and Grease/HEM	1664A	SM5520B	9070	Glass	pH<2 H_2SO_4 or HCl, ≤6°C	28 Days
Oxygen, Dissolved (Probe)		SM4500-O		Glass	None	15 minutes
Paint Filter Liquid Test.			9095	Plastic/Glass	None	N/A

Inorganic Parameters in Aqueous Samples (Cont.)

Parameter	Method			Container	Preservative	Max Hold Time
	EPA Water	Standard Methods	EPA Waste SW-846			
Phenol, Total	420.1/420.4		9065/9066	Glass	pH<2 H_2SO_4, ≤6°C	28 Days
Phosphorus, Orthophosphate	365.1/365.3	SM4500P		Plastic	Filter, ≤6°C	Filter within 15 minutes, Analyze within 48 hours
Phosphorus, Total	365.1 / 365.3 / 365.4	SM4500P		Plastic/Glass	pH<2 H_2SO_4, ≤6°C	28 Days
Silica, Dissolved		SM4500Si-D		Plastic	≤6°C	28 Days
Solids, Settleable		SM2540F		Glass	≤6°C	48 Hours
Solids, Total		SM2540B		Plastic/Glass	≤6°C	7 Days
Solids, Total Dissolved		SM2540C		Plastic/Glass	≤6°C	7 Days
Solids, Total Suspended	USGS I-3765-85	SM2540D		Plastic/Glass	≤6°C	7 Days
Specific Conductance	120.1	SM2510B	9050	Plastic/Glass	≤6°C	28 Days
Sulfate	375.2	SM4500S04 / ASTM D516	9036/9038	Plastic/Glass	≤6°C	28 Days
Sulfide, Reactive			Chapter 7	Plastic/Glass	None	28 Days
Sulfide, Total		SM4500S	9030	Plastic/Glass	pH>9 NaOH and ZnOAc; ≤6°C	7 Days
Sulfite		SM4500SO3		Plastic/Glass	None	15 minutes
Surfactants (MBAS)		SM5540C		Plastic/Glass	≤6°C	48 Hours
Total Organic Carbon (TOC)		SM5310B,C,D	9060	Glass	pH<2 H_2SO_4 or HCl, ≤6°C	28 Days
Total Organic Halogen (TOX)		SM5320	9020/9021	Glass (No headspace)	pH<2 H_2SO_4, ≤6°C	14 Days
Turbidity	180.1	SM2130B		Plastic/Glass	≤6°C	48 Hours

[2] Methods 9315 and 9320 both state that if samples are unpreserved, the samples should be brought to the lab within 5 days of collection, preserved in the lab, and then allowed to sit for a minimum of 16 hours before sample preparation/analysis.

RADCHEM PARAMETERS

Parameter	Method			Container	Preservative	Max Hold Time
	EPA Water	Standard Methods	EPA SW-846			
Gamma Emitting Radionuclides (see note 2)	901.1			Plastic/Glass	pH<2 HNO_3	180 days
Gross Alpha (NJ 48Hr Method)	NJAC 7:18-6			Plastic/Glass	pH<2 HNO_3	48 hours
Gross Alpha and Gross Beta (see note 2)	900.0		9310	Plastic/Glass	pH<2 HNO_3	180 days
Radium-226 (see note 2)	903.0/903.1			Plastic/Glass	pH<2 HNO_3	180 days
Radium-228 (see note 2)	904.0		9320	Plastic/Glass	pH<2 HNO_3	180 days
Radioactive Strontium (see note 2)	905.0			Plastic/Glass	pH<2 HNO_3	180 days
Total Alpha Radium (see note 2)	903.0		9315	Plastic/Glass	pH<2 HNO_3	180 days
Total Uranium (see note 2)	908.0	D5174-97		Plastic/Glass	pH<2 HNO3	180 days
Tritium	906.0			Glass	None	180 Days

[2] Methods 9315 and 9320 both state that if samples are unpreserved, the samples should be brought to the lab within 5 days of collection, preserved in the lab, and then allowed to sit for a minimum of 16 hours before sample preparation/analysis.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated water samples.	Sites.	Inadvertent exposure to contaminated water samples could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves and safety glasses when handling sample containers.
	Preservatives (HCL, HNO_3, H_2SO_4, NaOH and $Na_2S_2O_3$).	In bottles or added to bottles through sampling process.	Inadvertent exposure to preservatives could lead to adverse health effects.	Safety Data Sheets for each preservative chemical are available to all employees on the Pioneer company web site. Personnel will wear nitrile gloves and safety glasses when using preservatives and when handling the bottles. Refer to the Chemical Flushing Guidelines available inside vehicle's first aid kit for first-aid procedures in case of contact with preservatives.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Improper lifting.	Sites.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry coolers with samples.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two workers will lift/carry the coolers, if needed.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Personnel will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.

WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Personnel will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Outdoors.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement

			cause incidents resulting in adverse health effects and/or property damage.	stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDS	HCL, HNO_3, H_2SO_4, NaOH and $Na_2S_2O_3$. Additional Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-SA-01 Soil and Water Sample Packaging and Shipping.
TOOLS	Preservatives, sample container, ice, and cooler.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**05/28/2015**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**05/28/2015**

Revisions:

Revision	Description	Date

PURPOSE	This SOP describes the preparation and collection frequency of field quality control (QC) blanks and duplicate samples from water media.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Field Quality Control	At least one set of field QC samples will be prepared for each sampling event or as detailed in the project-specific Sampling and Analysis Plan (SAP) or Quality Assurance Project Plan (QAPP). The QC samples will be collected at a frequency of 1:20 or as detailed in the project specific SAP or QAPP. If the number of field QC samples taken is not equal to an integer multiple of the interval, the next higher multiple will be used. For example, if a frequency of 1:20 is indicated and 28 samples are taken, two QC samples will be prepared. All field QC samples shall be shipped with field samples to the contract laboratory as per SOP-SA-01 Soil and Water Sample Packaging and Shipping.
Field Blank or Bottle Blank	A minimum of one field bottle blank is required for every 20 natural samples. A bottle blank is a sample bottle containing di-ionized or analyte free water and preservatives and is prepared in the field. A sample bottle is randomly chosen from each lot of bottles received by the contract laboratory or supplier and di-ionized or analyte free water (depending on the analysis requested) is poured directly into the sample bottle while in the field, preserved, and shipped to the laboratory with the field samples. The field blank must be prepared in the field to evaluate the potential for contamination of a sample by site contaminants from sources not associated with the sample collected (e.g., air-borne dust). The appropriate sample number shall be placed on the bottle and recorded in the project logbook as a bottle blank.
Trip Blank	One trip blank is required per sampling event when volatile organic compound (VOC) samples are collected. Trip blanks are used to determine if samples were contaminated during storage

	and/or transportation back to the laboratory. A trip blank is only required for VOC sampling. A trip blank is prepared for field personnel by the contract laboratory staff prior to the sampling event and is shipped and stored in the same cooler with the investigative VOC samples throughout the sampling event. At no time after their preparation are trip blanks to be opened before they reach the laboratory. Trip blanks should be kept on ice in the cooler, along with the VOC samples during the entire sampling run. They must be stored in an iced cooler from the time of collection, while they are in the sampling vehicle, until they arrive at the laboratory.
Equipment, Cross Contamination, or Rinsate Blank	A minimum of one equipment blank is required for every 20 natural samples. Equipment blanks are collected after the completion of decontamination of sampling equipment and prior to sampling. An equipment blank is prepared by running distilled, de-ionized or analyte free water through or over the cleaned sampling equipment and adding the appropriate chemical preservatives. Equipment blanks are generally prepared in the field. One equipment blank must be prepared for each type of preservative and for any filtered samples. Equipment blanks will assess the adequacy of the decontamination process, as well as, the potential contamination of samples by the containers, preservatives and filters. The appropriate sample number shall be placed on the bottle and recorded in the project logbook as equipment blank.
Field Duplicate	A minimum of one duplicate is required for every 20 natural samples. A field duplicate is defined as a second sample, from the same location, collected in immediate succession, using identical techniques. This applies to all routine surface and groundwater collection procedures, including in-stream grab samples, bucket grab samples (e.g., from bridges), pumps, and other water sampling devices. Duplicate samples are sealed, handled, stored, shipped, and analyzed in the same manner as the primary sample. Duplicates should be submitted as “blind” meaning that the duplicate sample is given another name so it is not identified with the primary sample. Field duplicate assess sampling precision.
Temperature Blank	One temperature blank is required for each cooler shipped. A temperature blank is a vial of water that accompanies the samples that will be opened and tested upon arrival at the laboratory to ensure that the temperature of the contents of the sampling shipping container was within the required 4°C ± 2°.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated water samples. Preservatives (HCL, HNO_3, H_2SO_4, Zinc, Acetate, and NaOH).	Sites. In bottles or added to bottles through sampling process.	Inadvertent exposure to contaminated water samples could lead to adverse health effects. Inadvertent exposure to preservatives could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves and safety glasses when handling sample containers. Safety Data Sheets for each preservative chemical are available to all employees on the Pioneer company web site. Personnel will wear nitrile gloves and safety glasses when using preservatives and when handling the bottles. Refer to the Chemical Flushing Guidelines available inside vehicle's first aid kit for first-aid procedures in case of contact with preservatives.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Improper lifting.	Sites.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry packaged samples and coolers.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two workers will lift/carry packaged samples and coolers, if needed.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and	Workers will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work

			trips resulting in falls and injuries.	areas as dry as possible. Wear muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Outdoors.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			

HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves
APPLICABLE SDS	HCL, HNO_3, H_2SO_4, Zinc, Acetate, and NaOH. Additional Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-SA-01 Soil and Water Sample Packaging and Shipping.
TOOLS	Preservatives, sample glass bottles, ice, and cooler.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**12/11/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**12/11/2014**

Revisions:

Revision	Description	Date

PURPOSE	This SOP describes the preparation of Equipment Cross Contamination or Rinsate Blanks from a submersible pump.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS

Notes:

Equipment blanks, also known as rinsate blanks, are collected periodically after completing decontamination of sampling equipment and prior to resuming sampling. Equipment blanks assess the adequacy of the decontamination process and the potential contamination of samples by the containers, preservatives, and filters. Consequently, an equipment blank may be made of a single or multiple sample containers that represent the natural sampling process.

A minimum of one equipment blank is required for every 20 natural samples, regardless of the pump type used. Blanks are collected by running de-ionized or analyte free water through or over the cleaned sampling equipment and adding the appropriate chemical preservative. Field equipment rinsates should be collected in an environment free from dust and automobile exhaust. A separate blank must be collected for each type of preservative (e.g., HCl, HNO3, H2SO4, NaOH, etc.) used and each sample preparation method (e.g., unfiltered or filtered) used. If more than one type of pump is used for sampling (e.g., peristaltic pump, 12-volt submersible pump, Grunfoss Redi-Flo II pump, etc.), equipment blanks should be collected from the pump type used to collect the majority of samples, unless project-specific requirements differ. The following examples demonstrate how the number of equipment blanks may be determined.

> Example #1: A project requires 14 samples to be collected using a peristaltic pump and 5 samples to be collected using a 12-volt submersible pump. There are no project-specific equipment blank requirements. Only 1 equipment blank is necessary because less than 20 natural samples will be collected. The equipment blank should be collected from the peristaltic pump because it was used to collect a majority of the natural samples.
>
> Example #2: A project requires 23 samples to be collected using a 12-volt submersible pump, 5 samples to be collected using a Grunfoss Redi-Flow II pump, and 19 samples to be collected using a peristaltic pump. There are no project-specific equipment blank requirements. A minimum of 3 equipment blanks must be collected because the total number of natural samples is greater than 40. To evaluate potential cross contamination from each piece of sampling equipment, 1equipment blank should be collected from each of the 3 pumps.

Prior to starting the fieldwork, personnel should review the anticipated sampling conditions (e.g., well diameter, depth to water, historic contamination levels, etc.) to determine the likely number of equipment blanks. However, once in the field, personnel should be aware of conditions that may require adjustments to the number of equipment blanks (e.g., inaccurate well construction details, changes in water level, historic contamination, etc.).

1. Label blank container.	Label sample containers with the appropriate sample number as designated in the Sampling and Analysis Plan (SAP) or Quality Assurance Project Plan (QAPP). Place clear tape over the sample label. All sample containers collected for a natural sample should be duplicated for an equipment blank.
2. Blank container preparation.	Prepare the equipment blank container by removing the covering and rinsing with de-ionized (DI) water. Before a sampling event where more than one or two wells will be sampled, a new container for collecting equipment blanks should be prepared by triple rinsing with DI water and covering with foil or plastic. The container should be tall enough to submerge the pump and have a wide enough mouth that additional water can easily be added.
3. Remove pump.	Don a new pair of nitrile gloves and remove a decontaminated pump from its storage container making sure that the attached tubing (if appropriate) and pump do not contact any other surface (i.e., the ground). If needed attach a short piece of tubing to the pump.
4. Fill rinsate container.	Place the pump in the container dedicated for equipment blanks. A fresh jug of DI water should be opened and poured into the container to cover the pump.
5. Purge and collect samples.	Turn the pump on and continue to pour DI water into the container. Purge a minimum of 4 gallons through the pump as this simulates the purging done when sampling a well. Once an appropriate volume of water has been discharged from the pump, fill sample containers in the same order and method that they are filled when collecting a natural sample. If filtered samples are collected for field samples, a filter should be inserted into the discharge tube after all non-filtered samples have been collected and the appropriate sample containers should be filled.
6. Record in logbook.	The sample number and a description of the collection process should be recorded in the project logbook. The sample should be clearly identified in the logbook as an equipment blank.
7. Place on ice.	The sample containers should be placed in a cooler on ice as soon as possible after collection.
8. Empty and cover rinsate container.	Empty water out of dedicated equipment rinstate container and cover the container to avoid inadvertently contaminating the interior prior to the next blank sample.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated water samples.	Sites.	Inadvertent exposure to contaminated water samples could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves and safety glasses when handling sample containers.
	Preservatives (HCL, HNO_3, H_2SO_4, Zinc, Acetate, and NaOH).	In bottles or added to bottles through sampling process.	Inadvertent exposure to preservatives could lead to adverse health effects.	Safety Data Sheets for each preservative chemical are available to all employees on the Pioneer company web site. Personnel will wear nitrile gloves and safety glasses when using preservatives and when handling the bottles. Refer to the Chemical Flushing Guidelines available inside vehicle's first aid kit for first-aid procedures in case of contact with preservatives.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Improper lifting.	Sites.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry packaged samples, coolers, and large containers of water.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two workers will lift/carry packaged samples, coolers and large containers of water, if needed.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could	Workers will wear work boots with good traction and ankle support. Workers will be aware of working/walking surfaces and choose a path to avoid

			cause slips and trips resulting in falls and injuries.	hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Personnel will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Outdoors.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			

HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDS	HCL, HNO_3, H_2SO_4, Zinc, Acetate, and NaOH. Additional Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-SA-01 Soil and Water Sample Packaging and Shipping.
TOOLS	Preservatives, sample bottles, pumps, dedicated rinsate containers, DI water, ice, nitrile gloves, and cooler.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang (signature) **Julie Flammang**	**05/28/2015**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman (signature) **Tara Schleeman**	**05/28/2015**

Revisions:

Revision	Description	Date

PURPOSE	This SOP establishes the requirements for documenting and maintaining environmental sample chain of custody from point of origin to receipt of sample at the analytical laboratory. This procedure shall apply to all types of air, soil, water, sediment, biological, and/or core samples collected in environmental investigations by Pioneer Technical Services, Inc. (Pioneer). It is applicable from the time of sample acquisition until custody of the sample is transferred to an analytical laboratory.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.
DEFINITIONS	Chain of Custody: is an unbroken trail of accountability that ensures the physical security of samples, data, and records. Custody refers to the physical responsibility for sample integrity, handling, and/or transportation. Custody responsibilities are effectively met, if the samples are: • In the responsible individual's physical possession; • In the responsible individual's visual range after having taken possession; • Secured by the responsible individual so that no tampering can occur; or • Secured or locked by the responsible individual in an area in which access is restricted to authorized personnel only.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Project Manager's Responsibilities	The Project Manager is responsible for overall management of environmental sampling activities, designating sampling responsibilities to qualified personnel, and reviewing any changes to the sampling plan.
Field Team Leader's Responsibilities	The Project Manager may act as the Field Team Leader or may choose to appoint a Field Team Leader. The Field Team Leader is responsible for general supervision of field sampling activities and ensuring proper storage/transportation of samples from the field to the analytical laboratory. Chain of Custody forms will be reviewed for accuracy and completeness to preserve sample integrity from collection to receipt by an analytical lab by the Field Team Leader. The review of Chain of Custody forms may be delegated to qualified personnel.

	The Field Team Leader is responsible for sample custody until the sample has been properly relinquished as documented on the chain of custody form.
Field Sampler's Responsibilities	The Field Sampler is responsible for sample acquisition in compliance with technical procedures, initiating the Chain of Custody, and checking sample integrity and documentation prior to transfer. Field samplers are also responsible for initial transfer of samples consisting of physical transfer of samples directly to the internal laboratory or transferred to a shipping carrier, (e.g., United Parcel Service or Federal Express) for delivery.
Laboratory Technician's Responsibilities	The receiving Laboratory Technician is responsible for inspection of transferred samples to ensure proper labeling and satisfactory sample condition. Unacceptable samples will be identified and segregated. The Laboratory Project Manager will be notified. The Laboratory Technician will review the Chain of Custody for completeness and file as part of the project's permanent record.
Samples Handling and Chain of Custody Forms	All samples shall be collected and handled in accordance with SOP-SA-01 Soil and Water Sample Packaging and Shipping and SOP-SA-02 Sample Preservation and Containerization for Aqueous Samples, or methods described in the Sampling and Analysis Plan (SAP) or work plan (WP). Samples will be transported in insulated coolers with ice ('blue ice' is acceptable) as necessary to maintain temperature at 4 °C+/- 2 °C until receipt by the analytical laboratory. The Field Team Leader or designated Field Sampler shall initiate the Chain of Custody form for the initial transfer of samples. A Chain of Custody form will be completed and accompany every sample. The form includes the following information: • Project code; • Project name; • Samplers signature; • Sample identification; • Date sampled; • Time sampled; • Analysis requested; • Remarks; • Relinquishing signature, data, and time; and • Receiving signature, date, and time. The Field Sampler relinquishing custody and the responsible individual accepting custody shall sign, date, and note the time of transfer on the Chain of Custody form.

	Note: if the transporter is not an employee of Pioneer, the Field Sampler may identify the carrier and reference the bill of lading number in lieu of the transporter's signature. One copy of the Chain of Custody form shall be filed as a temporary record of sample transfer by the Field Sampler. The original form shall accompany the samples and shall be returned to Pioneer as part of the contracted laboratory Quality Assurance/Quality Control (QA/QC) requirements. The original form will be filed as part of the project's permanent records. The Project Manager (or designee) shall track the Chain of Custody to ensure timely receipt of samples by an analytical laboratory.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated water/soil samples.	Outside of bottles.	Inadvertent exposure to contaminated water/soil samples could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves and safety glasses when handling sample containers.
	Preservatives (HCL, HNO_3, H_2SO_4, Zinc, Acetate, and NaOH).	Outside of bottles.	Inadvertent exposure to preservatives could lead to adverse health effects.	Safety Data Sheets for each preservative chemical are available to all employees on the Pioneer company web site. Personnel will wear nitrile gloves and safety glasses when handling the bottles. Refer to the Chemical Flushing Guidelines available inside vehicle's first aid kit for first-aid procedures in case of contact with preservatives.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Improper lifting.	Sites.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry packaged samples and coolers.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two workers will lift/carry packaged samples and coolers, if needed.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in	Workers will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible.

			falls and injuries.	
WEATHER	Not applicable.			
RADIATION	Not applicable.			
BIOLOGICAL	Not applicable.			
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDS	HCL, HNO_3, H_2SO_4, Zinc, Acetate, and NaOH. Additional Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-SA-01 Soil and Water Sample Packaging and Shipping and SOP-SA-02 Sample Preservation and Containerization for Aqueous Samples.
TOOLS	Seals and labels; chain of custody forms; chain of custody seals (provided by contracted laboratory); packing and shipping materials; and cooler and ice.
FORMS/CHECKLIST	Chain of Custody Forms.

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**12/17/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**12/17/2014**

Revisions:

Revision	Description	Date

PURPOSE	This SOP establishes the requirements for documenting and maintaining field logbooks and photographs. These procedures shall apply to all types of air, soil, water, sediment, biological, and/or core samples collected in environmental investigation by Pioneer Technical Services, Inc. (Pioneer). These procedures apply from the time field work begins until site activities are completed.
SCOPE	This practice has been prepared for the Pioneer workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
1. Logbooks.	A designated field logbook will be used for each field project. If requested by the Project Manager, use a separate field logbook for each field task within a larger project. Label each logbook with the project name, dates that it covers, and logbook number. Use a waterproof marker, such as a Sharpie©, to write down the information. The logbooks will be bound and have consecutively numbered pages. The information recorded in these logbooks shall be written in ink. Begin a new page for each days notes. Write on every line of the logbook. If a blank space is necessary for clarity, such as a change of subject, skip one line before beginning the new subject. Do not skip any pages or parts of pages unless a day's activity ends in the middle of a page. Draw a diagonal line on any blank spaces of four lines or more to prevent unauthorized entries. The author will initial and date entries at the end of each day. All corrections will consist of a single line-out deletion in ink, followed by the author's initials and the date. Information not related to the project should not be entered in the logbook. The language used in the logbook should be factual and objective. These bound logbooks shall include the following entries: 1. A description of the field task. 2. Time and date fieldwork started. 3. Location and/or a description of the work areas including sketches, if needed, any maps or references needed to identify locations, and sketches of construction activities. If the location has been documented in the logbook during/prior visits, only changes in conditions should be noted. 4. Names and company affiliations of field personnel.

	5. Name, company affiliation or address, and phone number of any field contacts or official site visitors. 6. Meteorological conditions at the beginning of fieldwork and any ensuing changes in these conditions. 7. Details of the fieldwork performed and reference to field data sheets, if used. 8. Deviation from the task-specific Sampling and Analysis Plan (SAP), Work Plan (WP), or Standard Operating Procedures (SOP). 9. All field measurements made. 10. Any field laboratory analytical results. 11. Personnel and equipment decontamination procedures, if appropriate. For any field sampling work, the following entries should be made: 1. Sample location and number. 2. Sample type and amount collected. 3. Date and time of sample collection. 4. Type of sample preservation. 5. Split samples taken by other parties. Note the type of sample, sample location, time/date, name of person for whom the split was collected, that person's company, and any other pertinent information. 6. Sampling method, particularly any deviations from the SOP. 7. Documentation or reference of preparation procedures for reagents or supplies that will become an integral part of the sample, if available. This information may not be available for water or soil sampling bottles that come preserved from the laboratory or for preservatives provided by the laboratory. Bottle blanks will need to be used to evaluate the provided reagents. 8. The laboratory where the samples will be sent. No bound field logbooks will be destroyed or thrown away even if they are illegible or contain inaccuracies that require a replacement document.
2. Photographs.	Take photographs of field activities using a digital camera. Photographs should include a scale in the picture when practical. Telephoto or wide-angle shots will not be used, since they cannot be used in enforcement meetings. The following items shall be recorded in the bound field logbook or on a field data sheet for each

	photograph taken: 1. The photographer's name, the date, the time of the photograph, and the general direction faced. 2. A brief description of the subject and the fieldwork portrayed in the picture. 3. Sequential number of the photograph. An electronic copy and/or a hard copy of the photographs shall be placed in task files in the field office after each day of field activities. Supporting documentation from the bound field logbooks or field data sheets shall be photocopied and placed in the task files to accompany the photographs once the field activities are complete.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Not applicable.			
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Not applicable.			
GRAVITY	Not applicable.			
WEATHER	Not applicable.			
RADIATION	Not applicable.			
BIOLOGICAL	Not applicable.			
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Not applicable.			
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	
APPLICABLE SDS	Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	
TOOLS	Field logbook, Sharpie©, black pen, digital camera, and field data sheets.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**12/17/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**12/17/2014**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for conducting field filtration of water.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Field Sample Filtration	
Notes	The general procedures listed below are applicable for field filtration of water samples for subsequent analysis of dissolved analytes. Refer to the following SOPs for the sampling setup in which filtering will occur: SOP-GW-02 Sampling with a Bailer SOP-GW-10 Purging and Sampling with a 12-Volt Submersible Pump SOP-GW-10A Purging and Sampling with a Low Flow Submersible Pump SOP-GW-10B Purging and Sampling with Grunfoss Redi-Flo Submersible Pump SOP-GW-10C Purging and Sampling with a Peristaltic Pump SOP-GW-13 Sampling Groundwater from a Tap
Field Filtering When Sampling With A Bailer	
Notes	Prior to the sample event include an extra 1-liter sample container for each sample site on the laboratory bottle order. If necessary, a 1-liter sample container can be decontaminated as described in SOP-DE-02 Equipment Decontamination. This is not recommended as there is a potential for introducing contamination. A new disposable filter is to be used for each sampling site. A peristaltic pump will be used for filtering the sample. Order peristaltic pump tubing: approximately 18 inches of silicon tubing and 12 inches of polyethylene tubing per sampling site.
1. Setup.	Follow the procedures as outlined in SOP-GW-02 Sampling with a Bailer through the step for collecting samples.

2. Sample for filtering.	While filling sample containers, also fill the extra 1- liter unpreserved sample container, this water will be used for filtering. Install new tubing in the peristaltic pump. Insert an in-line high capacity (0.45 µm) disposable filter on the tubing. Make sure that the filter is inserted so that the flow arrow is pointed toward the discharge end of the tubing. Start the pump and let a small amount of water flow through the filter before filling the sample container. Hold the filter at an angle to ensure no unfiltered water from the tubing leaks into the sample container and only the filtered water enterers the sample container. If water stops discharging from filter, replace filter with a new filter. If one of the sample containers (unpreserved) for the actual sample was used in lieu of an extra container to collect the water for filtering, refill the container after filtration is completed. Follow the SOP-SA-02 Sample Preservation and Containerization for Aqueous Samples to complete sample collection. If extremely turbid water is encountered place an in-line high capacity (10 µm) disposable filter before the in-line high capacity (0.45 µm) disposable filter.
3. Label, store, and ship samples.	Label the sample bottle as appropriate and place in a cooler. Ship with other samples in accordance with SOP-SA-01 Soil and Water Sample Packaging and Shipping.
4. Dispose of used bailer, tubing, filters and extra 1-liter sample container.	Bailer, tubing, filters and the extra 1-liter sample container used in the well sampling will be disposed of in accordance with SOP-DE-03 Investigation Derived Waste Handling.

Filtering Sample with 12-Volt Submersible Pump, Low Flow Submersible Pump and Grunfoss Redi-Flo II Submersible Pump

Note	A new disposable filter is to be used for each sampling site.
1. Setup.	Follow the procedures as outlined in the appropriate SOP listed above through the step for collecting samples.
2. Sample for filtering.	After filling the unfiltered sample containers as detailed in SOP-SA-02 Sample Preservation and Containerization for Aqueous Samples insert an in-line high capacity (0.45 µm) disposable filter in the discharge end of the tubing. Make sure that the filter is inserted so that the flow arrow is pointed toward the discharge end of the tubing. Let a small amount of water flow through the filter before filling the sample container. Hold the filter at an angle to ensure no unfiltered water from the tubing leaks into the sample container and only the filtered water enterers the sample container. If water stops discharging from filter replace filter with a new filter. If one of the sample containers (unpreserved) for the actual sample was used in lieu of an extra container to collect the water for filtering, refill the container after filtration is completed. Follow the SOP-SA-02 Sample Preservation and

	Containerization for Aqueous Samples to complete sample collection. If extremely turbid water is encountered place an in-line high capacity (10 µm) disposable filter before the in-line high capacity (0.45 µm) disposable filter.
3. Label, store, and ship samples.	Label the sample bottle as appropriate and place in a cooler. Ship with other samples in accordance with SOP-SA-01 Soil and Water Sample Packaging and Shipping.
4. Dispose of used disposable tubing and filters.	Dispose of tubing and filters used in the well sampling in accordance with SOP-DE-03 Investigation Derived Waste Handling.

Filtering Sample with Peristaltic Pump

Note	A new disposable filter is to be used for each sampling site.
1. Setup.	Follow the procedure for pump setup and purging as outlined in the SOP-GW-10C Purging and Sampling with a Peristaltic Pump through the step to collect samples.
2. Sample for filtering.	After filling the unfiltered sample containers as detailed in SOP-SA-02 Sample Preservation and Containerization for Aqueous Samples place an in-line high capacity (0.45 µm) disposable filter on the discharge end of the tubing. Make sure that the filter is inserted so that the flow arrow is pointed toward the discharge end of the tubing. Let a small amount of water flow through the filter before filling the sample container. Hold the filter at an angle to ensure no unfiltered water from the tubing leaks into the sample container and only the filtered water enterers the sample container. If water stops discharging from filter replace filter with a new filter. Follow the SOP-SA-02 Sample Preservation and Containerization for Aqueous Samples to complete sample collection. If extremely turbid water is encountered place an in-line high capacity (10 µm) disposable filter before the in-line high capacity (0.45 µm) disposable filter.
3. Label, store, and ship samples.	Label the sample bottle as appropriate and place in a cooler. Ship with other samples in accordance with SOP-SA-01 Soil and Water Sample Packaging and Shipping.
4. Dispose of used disposable tubing and filters.	Dispose of tubing and filters used in the well sampling in accordance with SOP-DE-03 Investigation Derived Waste Handling.

Filtering Sample from a Tap	
Notes	Prior to the sample event include an extra 1 liter sample container per sample site on the laboratory bottle order. If necessary a 1-liter sample container can be decontaminated as describer in SOP-DE-02 Equipment Decontamination. This is not recommended as there is a potential for introducing contamination. A new disposable filter is to be used for each sampling site. A peristaltic pump will be used for filtering the sample. Order peristaltic pump tubing: approximately 18 inches of silicon tubing and 12 inches of polyethylene tubing per sampling site.
1. Setup.	Follow the procedure for setup and purging as outlined in the SOP-GW-13 Sampling Groundwater From a Tap through the step for collecting samples.
2. Sample for filtering.	While filling sample containers, also fill the extra 1- liter unpreserved sample container, this water will be used for filtering. Install new tubing in the peristaltic pump. Insert an in-line high capacity (0.45 µm) disposable filter on the tubing. Make sure that the filter is inserted so that the flow arrow is pointed toward the discharge end of the tubing. Start the pump and let a small amount of water flow through the filter before filling the sample container. Hold the filter at an angle to ensure no unfiltered water from the tubing leaks into the sample container and only the filtered water enterers the sample container. If water stops discharging from filter replace filter with a new filter. If one of the sample containers (unpreserved) for the actual sample was used in lieu of an extra container to collect the water for filtering, refill the container after filtration is completed. Follow the SOP-SA-02 Sample Preservation and Containerization for Aqueous Samples to complete sample collection. If extremely turbid water is encountered place an in-line high capacity (10 µm) disposable filter before the in-line high capacity (0.45 µm) disposable filter.
3. Label, store, and ship samples.	Label the sample bottle as appropriate and place in a cooler. Ship with other samples in accordance with SOP-SA-01 Soil and Water Sample Packaging and Shipping.
4. Disposable tubing, filters and if used extra 1 liter sample container.	Disposable tubing, filters and the extra 1 liter sample container will be disposed of in accordance with SOP-DE-03 Investigation Derived Waste Handling.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated water and filters.	Testing sites.	Inadvertent exposure to contaminated water and filters could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Personnel will wear nitrile gloves and safety glasses.
	Preservatives (HCL, HNO_3, H_2SO_4, Zinc, Acetate, and NaOH).	In bottles or added to bottles through sampling process.	Inadvertent exposure to preservatives could lead to adverse health effects.	Safety Data Sheets for each preservative chemical are available to all employees on the Pioneer company website. Personnel will wear nitrile gloves and safety glasses when adding preservatives to sample bottles and when handling the bottles. Refer to the Chemical Flushing Guidelines available inside vehicle's first aid kit for first-aid procedures in case of contact with preservatives.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Improper lifting.	Testing sites.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry tools and equipment.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two employees will lift objects, if necessary.
	Bending, squatting, and kneeling.	During sample collection.	Bending, squatting, and kneeling during sample collection could result in muscle/back strains or other injuries.	Employees should stretch prior to starting work and they will take breaks when necessary.

GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Workers will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Employees will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Not applicable.			

PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, nitrile gloves, and work gloves.
APPLICABLE SDS	HCL, HNO3, H2SO4, Zinc, Acetate, and NaOH. Additional Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	Map with site location and sample locations.
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-GW-02 Sampling with A Bailer SOP-GW-10 Purging and Sampling with a 12-Volt Submersible Pump SOP-GW-10A Purging and Sampling with a Low Flow Submersible Pump SOP-GW-10B Purging and Sampling with Grunfoss Redi-Flo Submersible Pump SOP-GW-10C Purging and Sampling with a Peristaltic Pump SOP-GW-13 Sampling Groundwater From a Tap SOP-DE-02 Equipment Decontamination SOP-SA-02 Sample Preservation and Containerization for Aqueous Samples SOP-SA-01 Soil and Water Sample Packaging and Shipping SOP-DE-03 Investigation Derived Waste Handling
TOOLS	Bailer, filter, tubing, pump, sample collection tools, cooler, sample bottles, and preservatives.

FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang	**05/28/2015**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman	**05/28/2015**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for field measurement of pH in water.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
1. Prepare the pH meter.	Pioneer owns and operates different brands and models of pH field measurement meters. All units, in general, have automatic temperature correction (ATC) capabilities. Prior to using a pH meter, verify that it has the ATC function. User manuals for each meter are available and the specific directions for calibrating and measuring pH with that meter should be followed. Calibrate pH meter in the field at the beginning of each day and if a standard check is out of calibration. Record the calibration information in the field logbook. 1. For a new probe, prepare the pH probe according to the directions in the electrode user guide. 2. Connect the probe to the appropriate connection on the meter. 3. Turn the meter on and make sure it is in the pH measurement mode. Calibrate instrument as described in the meter specific operating manual.
2. Calibrate the meter.	The following is a general summary for instrument calibration: 1. Rinse the ATC pH probe in de-ionized water. 2. Turn on meter and immerse the ATC pH probe in a pH 7 buffer solution. Calibrate meter to pH 7 allowing enough time for meter to stabilize. 3. Rinse ATC pH probe with de-ionized water. 4. Immerse ATC pH probe in a pH 4 buffer solution. Calibrate meter to pH 4 allowing enough time for meter to stabilize. 5. Rinse pH and temperature probe with de-ionized water. 6. Immerse ATC pH probe in a pH 10 buffer solution. Calibrate meter to pH 10

	allowing enough time for meter to stabilize. 7. Record the slope reading in the field logbook. 8. Recheck meter calibrations with the pH 4, pH 7 and pH 10 calibration solutions. Repeat the calibration process (steps 2-4), if values for any of the final pH check is more than 0.1 units from the appropriate value.
3. Take field measurements.	The following is a general summary for field measurement of pH: 1. Rinse beaker with sample water three times. 2. Rinse ATC pH probe with de-ionized water. 3. Fill beaker with sample water. 4. Turn on meter and immerse ATC pH probe in sample water. Stir sample for thorough mixing. Read and record pH to the nearest 0.01 unit once pH reading has stabilized. 5. Rinse electrodes with de-ionized water and store in carrying case. Note: pH may also be measured by placing the probe directly into the water body being tested. The probe must be moved slowly in a circular motion when measuring stagnant water.
Important information about meter.	1. Store meter in case during transport. 2. Check batteries before taking meter into the field. Carry spare batteries and de-ionized water for rinsing probe. 3. Inspect probe for damage or dirt. 4. Dust and wipe the meter with a damp cloth. If necessary, warm water or mild water based detergent can be used to clean the case. Immediately remove any spilled substance from the meter using the proper cleaning procedure for the type of spill. 5. If meter readings are erratic, replace the probe. If readings continue to be erratic, return the meter to factory for repair.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated water.	Testing sites, during pH measurements.	Inadvertent exposure to contaminated water could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Personnel will wear nitrile gloves and safety glasses when taking measurements.
	Potential contact with pH buffer solutions.	Equipment calibration.	Inadvertent exposure to pH buffer solutions could lead to adverse health effects (e.g., irritation of eye, skin, and/or respiratory tract).	Personnel will practice proper personal hygiene – wash hands prior to eating and after calibrating equipment. Personnel will wear nitrile gloves and safety glasses when handling pH buffer solutions.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Bending, squatting, and kneeling.	During pH measurements.	Bending, squatting, and kneeling during pH measurements could result in muscle/back strains or other injuries.	Employees should stretch prior to starting work and they will take breaks when necessary.
	Drowning and/or entrapment hazards.	Bodies of water, during pH measurements.	If employees need to stand in bodies of water to take measurements, they could be exposed to drowning and/or entrapment hazards from soft soils and/or sudden changes	If necessary, workers will use rods to test soil stability and/or depth of water as they walk to sample locations. In addition, personnel may be required to wear life vests when crossing deeper bodies of water. When possible, workers will not enter the water body and take measurements from the bank.

			in depth of water.	
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Workers will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Personnel will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Hypothermia/ frostbite.	Sites where air temperature is 35.6°F (2°C) or less.	Workers who become immersed in water or whose clothing becomes wet may be exposed to hypothermia and/or frostbite.	Employees will change clothing if it becomes wet. When applicable, employees will wear waders to prevent clothing from getting wet.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.

BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDS	pH 4, pH7, and pH10 buffer solutions. Additional Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	Map with site location and sample locations.
RELATED SOPs/PROCEDURES/ WORK PLANS	
TOOLS	pH field measurement meters, spare batteries for the pH field measurement meters, de-ionized water, pH 7 buffer solution, pH 4 buffer solution, pH 10 buffer solution, beaker, and field logbook.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**12/17/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**12/17/2014**

Revisions:

Revision	Description	Date

	SOP-WFM-02; FIELD MEASUREMENT OF OXIDATION REDUCTION POTENTIAL IN WATER	DATE ISSUED: 12/17/2014 REVISION: 0 PAGE 1 of 9

PURPOSE	To provide standard instructions for field measurements of oxidation reduction potential in water.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Important information about meter's calibration.	Pioneer owns and operates different brands and models of Oxidation Reduction Potential (ORP) field measurement meters. All units, in general, have automatic temperature correction (ATC) capabilities. Prior to using an ORP meter, check that it does have the ATC function. User manuals for each meter are available and the specific directions for calibrating and measuring ORP with that meter should be followed. Measure the raw millivolt (mV) values of an electrode in the mV mode. Calibrate the relative millivolt (RmV) values of a redox electrode for ORP measurements in the relative mV/ORP mode. Note: the mV measurements are raw readings and cannot be calibrated. Use the relative mV mode to calibrate mV measurements. The relative mV mode can be used to calibrate the ORP electrode so the electrode reads the E_HmV values in samples. When an ORP electrode is calibrated to read E_HmV values, the resulting sample reading can be compared among multiple meters and electrode systems. Pioneer uses Thermo Scientific ORION 3 Star or 5 Star Portable Meters set to the millivolt (mV) mode for ORP readings. An Orion 9179BNMD epoxy low maintenance ORP/ATC Triode is attached to the meter. The Orion Star meters can perform an automatic ORP calibration adjusted for temperature. Listed below is the general calibration procedure. Refer to the meter specific operating manual for detailed calibration instructions.
1. Prepare electrode.	1. Remove the protective shipping cap from the sensing element and save the cap for storage. 2. Clean any salt deposits from the exterior of the electrode by rinsing with distilled water. 3. Shake the electrode downward (similar to a clinical thermometer) to remove air bubbles.

	4. Connect the electrode to the meter.
2. Connect the electrode to the meter.	1. Insert the ORP connector (large diameter) in the pH or BNC electrode input jack on the meter and the reference electrode connector (small diameter) into the reference electrode input jack.
3. Calibrate the meter.	All field meters must be calibrated prior to use. Calibration shall be performed at a minimum of once per day for each day of instrument use. Calibration shall be performed prior to the first measurements of the day. All calibration results should be recorded in the field logbook. 1. Set the meter to the RmV mode referring to the specific meter's user guide for detailed instructions. 2. Rinse the electrode with de-ionized or distilled water and place the ORP electrode in ORP standard, Orion 967901. Always use fresh ORP standard for calibrations. Empty the ORP calibration container in Pioneer Calibration Kit, rinse the bottle with fresh ORP solution, empty and then pour a sufficient amount of the calibration fluid into the bottle to cover the bottom of the electrode. 3. Wait for the RmV icon to quit flashing. 4. The Orion Star meters will automatically calculate the EHmV. Small adjustments may be required to the meter to achieve the EHmV value of the ORP standard at the measured temperature. Information provided in the Thermo Orion User Guide for Redox/ORP Electrodes or Table 1 attached can be used as a reference for the appropriate reading. Adjust the meter referring to the meter user's guide for detailed instructions on adjusting the reading. 5. Press the measure symbol to end the calibration. The milllivolt offset will be displayed and the meter will proceed to the measurement mode. 6. Record the calibration information in the logbook.
4. Conduct field measurements.	Field ORP measurements for surface water may be made by direct submersion of the instrument probe into the sample stream. If flow is turbulent or shallow, or if direct immersion of the probe would risk damaging the probe, a grab sample can be collected and immediate measurement of the grab sample conducted. Field ORP measurements of groundwater may be made by inserting the probe into a flow through device or by collection of a grab sample and immediate analysis of the grab sample in the field. Specific requirements may be listed in the Sampling and Analysis Plan (SAP) or work plan. Field ORP is measured in units of mV on all Pioneer's meters. Refer to the meter specific operating manual for measurement instructions. Listed below are general measurement instructions:

	1. Rinse the electrode with distilled or de-ionized water. Shake off any excess water and blot the electrode dry with lint-free tissue. 2. Check and make sure that the meter is measuring in mVs. 3. Place the electrode directly into the water to be measured. If the probe cannot be placed directly into the water being measured, rinse a decontaminated beaker with sample water three times. Fill the beaker with the water to be measured. 4. Continuously stir or move the probe through the sample at a rate of about one foot per second. 5. If the meter is in the continuous measurement mode, it will start reading immediately and continuously update the display. The mV icon will flash until the reading is stable. 6. Read and record the result in the field logbook or on a field data sheet. 7. Remove the electrode from the sample, rinse it with distilled or de-ionized water, and blot it dry before inserting the probe into the storage sleeve.
Important information about the meter.	1. Store meter in case during transport. 2. Check batteries before taking meter into the field. Carry spare batteries and de-ionized water for rinsing probe. 3. Inspect probe for damage or dirt. 4. Dust and wipe the meter with a damp cloth. If necessary, warm water or mild water based detergent can be used to clean the case. Immediately remove any spilled substance from the meter using the proper cleaning procedure for the type of spill. 5. If meter readings are erratic, replace the probe. If measurement readings continue to be erratic, return the meter to factory for repair.

HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	*HAZARDS*	*WHERE*	*HOW, WHEN, RESULT*	*CONTROLS*
CHEMICAL	Potential contact with contaminated water.	Testing sites, during field measurements.	Inadvertent exposure to contaminated water could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Personnel will wear nitrile gloves and safety glasses when taking measurements.
	Potential exposure to ORP standard solution.	Equipment calibration.	ORP standard solution is moderately toxic, if ingested. It may also irritate eyes and skin.	Personnel will practice proper personal hygiene – wash hands prior to eating and after calibrating equipment. Personnel will wear nitrile gloves and safety glasses when handling the ORP standard solution.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Bending, squatting, and kneeling.	During field measurements.	Bending, squatting, and kneeling during field measurements could result in muscle/back strains or other injuries.	Employees should stretch prior to starting work and they will take breaks when necessary.
	Drowning and/or entrapment hazards.	Bodies of water, during field measurements.	If employees need to stand in bodies of water to take measurements, they could be exposed to drowning and/or entrapment hazards from soft soils and/or sudden changes	If necessary, workers will use rods to test soil stability and/or depth of water as they walk to sample locations. In addition, personnel may be required to wear life vests when crossing deeper bodies of water. When possible, workers will not enter the water body and take measurements from the bank.

			in depth of water.	
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Personnel will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Personnel will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Hypothermia/ frostbite.	Sites where air temperature is 35.6°F (2°C) or less.	Workers who become immersed in water or whose clothing becomes wet may be exposed to hypothermia and/or frostbite.	Employees will change clothing if it becomes wet. When applicable, employees will wear waders to prevent clothing from getting wet.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.

BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDS	ORP Standard Solution. Additional Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	Map with site location and sample locations.
RELATED SOPs/PROCEDURES/ WORK PLANS	
TOOLS	ORP field measurement meters, ORP standard solution, calibration kit, spare batteries for the meters, distilled water or de-ionized water, lint-free tissue, beaker, and field logbook or field data sheet.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang (signature) **Julie Flammang**	**12/17/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman (signature) **Tara Schleeman**	**12/17/2014**

Revisions:

Revision	Description	Date

Table 1 – Page 1

Table 1– ORP Standard Values
Absolute mV values may vary by ± 60 mV

Temperature (°C)	E_H Value (mV)	Absolute Value with Cat. No. 900011 Filling Solution (mV)	Absolute Value with Cat. No. 900001 Filling Solution (mV)
0	438	218	176
1	437	218	176
2	437	218	176
3	436	218	176
4	435	218	176
5	435	218	176
6	434	218	176
7	433	218	176
8	433	218	175
9	432	219	175

Table 1 – Page 2

Temperature (°C)	E_H Value (mV)	Absolute Value with Cat. No. 900011 Filling Solution (mV)	Absolute Value with Cat. No. 900001 Filling Solution (mV)
10	431	219	175
11	430	219	175
12	430	219	175
13	429	219	175
14	428	219	175
15	428	219	175
16	427	219	174
17	426	219	174
18	425	219	174
19	424	219	174
20	424	219	174
21	423	219	174
22	422	219	174
23	421	219	173
24	420	220	173
25	420	220	173
26	419	220	173
27	418	220	173
28	417	220	172
29	416	220	172
30	415	220	172
31	414	220	172
32	413	220	172
33	412	220	171
34	412	220	171
35	411	220	171
36	410	220	171
37	409	220	171
38	408	220	170
39	407	220	170
40	406	220	170
41	405	220	170
42	404	220	169
43	403	220	169
44	402	220	169
45	401	220	169
46	400	220	168
47	399	220	168
48	398	220	168
49	397	220	168
50	396	220	167

PURPOSE	To provide standard instructions for field measurements of specific conductance.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Important information about the meter.	Pioneer owns and operates different brands and models of specific conductance (SC) field measurement meters. All the units, in general, have automatic temperature correction (ATC) capabilities. Prior to using a SC meter check that it does have the ATC function. User manuals for each meter are available and the specific directions for calibrating and measuring SC with that meter should be followed. The following is a general summary for field measurement of SC.
1. Calibrate the meter.	All field meters must be calibrated prior to use. Calibration shall be performed at a minimum of once per day for each day of instrument use. Calibration shall be performed prior to the first measurements of the day. Refer to the meter specific operating manual for calibration instructions. Listed below are general calibration requirements: 1. For a new probe, prepare the SC probe according to the directions in the electrode user guide. 2. Connect the probe to the appropriate connection on the meter. 3. Turn the meter on and make sure it is in the conductivity measurement mode. Calibrate instrument as described in the meter specific operating manual. Unless specified in the Sampling and Analysis Plan (SAP) or work plan, one conductivity standard is used for calibration. Unless directed otherwise, use the 1413 micromhos/centimeter (µs/cm) calibration standard present in all of Pioneers calibration cases. Make sure that the calibration standard in the case is fresh. The container of calibration standard should be emptied, rinsed with new calibration standard and filled prior to a field sampling event. Replace batteries and try fresh calibration solutions if meter does not calibrate properly. 4. Record the calibration results in the field logbook. If the meter displays an average calculated cell constant, record this in the field logbook. 5. Once the SC meter is in measure mode, measure the calibration standard and

	record this result and the measurement temperature in the field logbook. 6. Re-measure the calibration fluid at the end of the day and note any drift. Record the information in the field logbook.
2. Conduct field measurements.	Field conductivity measurements for surface water may be made by direct submersion of the instrument probe into the sample stream. When flow is turbulent or shallow, or when direct immersion of the probe would risk damaging the probe, measurements may be made by collection of a grab sample and immediate analysis of the grab sample in the field. Field SC measurements of groundwater may be made by inserting the probe into a flow through device or by collection of a grab sample and immediate analysis of the grab sample in the field. Specific requirements may be listed in the SAP or work plan. Field SC is measured in units of µS/cm (micromhos/centimeter) or mS/cm (millihos/centimeters) on all Pioneer meters. Refer to the meter specific operating manual for measurement instructions. Listed below are general measurement instructions: 1. If the probe cannot be placed directly into the water being measured, rinse the decontaminated beaker with sample water three times. 2. Fill the beaker with the water to be measured. 3. With the meter in measurement mode, rinse the conductivity cell with distilled water, blot dry with a lint-free tissue and place the cell into the water being measured. 4. Submerge conductivity probe in sample so that flow cell holes are immersed and wait for the readings to stabilize. 5. Read and record the SC result in the field logbook or on a field data sheet making sure that the correct units are recorded, either µS/cm or mS/cm. Record the sample temperature to the nearest 0.1 degree Celsius (°C) from the conductivity meter after temperature has equilibrated. 6. Repeat the above steps for all samples. 7. When all samples have been measured, store the electrode according to their specific user guides.
Important information about the meter.	1. Store meter in case during transport. 2. Check batteries before taking meter into the field. Carry spare batteries and de-ionized water for rinsing probe. 3. Inspect probe for damage or dirt.

	4. Dust and wipe the meter with a damp cloth. If necessary, warm water or mild water based detergent can be used to clean the case. Immediately remove any spilled substance from the meter using the proper cleaning procedure for the type of spill. 5. If meter readings are erratic, replace the probe. If readings continue to be erratic, return the meter to factory for repair.

HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated water.	Testing sites, during field measurements.	Inadvertent exposure to contaminated water could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Personnel will wear nitrile gloves and safety glasses when taking measurements.
	Exposure to 1413 µs/cm calibration standard solution.	Equipment calibration.	The calibration standard solution may cause irritation of eyes and skin.	Personnel will practice proper personal hygiene – wash hands prior to eating and after calibrating equipment. Personnel will wear nitrile gloves and safety glasses when handling the calibration standard solution.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Bending, squatting, and kneeling.	During field measurements.	Bending, squatting, and kneeling during field measurements could result in muscle/back strains or other injuries.	Employees should stretch prior to starting work and they will take breaks when necessary.
	Drowning and/or entrapment hazards.	Bodies of water, during field measurements.	If employees need to stand in bodies of water to take measurements, they could be exposed to drowning and/or entrapment hazards from soft soils and/or sudden changes in depth of water.	If necessary, personnel will use rods to test soil stability and/or depth of water as they walk to sample locations. In addition, personnel may be required to wear life vests when crossing deeper bodies of water. When possible, workers will not enter the water body and take measurements from the bank.

GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Personnel will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Personnel will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Hypothermia/ frostbite.	Sites where air temperature is 35.6°F (2°C) or less.	Workers who become immersed in water or whose clothing becomes wet may be exposed to hypothermia and/or frostbite.	Employees will change clothing if it becomes wet. When applicable, employees will wear waders to prevent clothing from getting wet.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.

BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS

This section to be completed with concurrence from the Safety and Health Manager.

REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDS	1413 µs/cm calibration standard solution. Additional Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	Map with site location and sample locations.
RELATED SOPs/PROCEDURES/ WORK PLANS	
TOOLS	Specific conductance field measurement meter, calibration standard solution, calibration kit, spare batteries for the meter, distilled water or de-ionized water, lint-free tissue, beaker, and field logbook or field data sheet.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang (signature) **Julie Flammang**	**12/17/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman (signature) **Tara Schleeman**	**12/17/2014**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for field measurement of water temperature.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Note	Pioneer uses a pH field measurement meter for measuring temperature.
1. Prepare the pH meter for measuring water temperature.	Pioneer owns and operates different brands and models of pH field measurement meters. All units, in general, have automatic temperature correction (ATC) capabilities. Prior to using a pH meter, verify that it has the ATC function. User manuals for each meter are available and the specific directions for calibrating and measuring pH with that meter should be followed. Calibrate pH meter in the field at the beginning of each day and if a standard check is out of calibration. Record the calibration information in the field logbook. 1. For a new probe, prepare the pH probe according to the directions in the electrode user guide. 2. Connect the probe to the appropriate connection on the meter. 3. Turn the meter on and make sure it is in the pH measurement mode. Calibrate instrument as described in the meter specific operating manual.
2. Calibrate the meter.	The following is a general summary for instrument calibration: 1. Rinse the ATC pH probe in de-ionized water. 2. Turn on meter and immerse the ATC pH probe in a pH 7 buffer solution. Calibrate meter to pH 7 allowing enough time for meter to stabilize. 3. Rinse ATC pH probe with de-ionized water. 4. Immerse ATC pH probe in a pH 4 buffer solution. Calibrate meter to pH 4 allowing enough time for meter to stabilize. 5. Rinse pH and temperature probe with de-ionized water.

	6. Immerse ATC pH probe in a pH 10 buffer solution. Calibrate meter to pH 10 allowing enough time for meter to stabilize. 7. Record the slope reading in the field logbook. 8. Recheck meter calibrations with the pH 4, pH 7 and pH 10 calibration solutions. Repeat the calibration process (steps 2-4), if values for any of the final pH check is more than 0.1 units from the appropriate value. Record pH and temperature calibration recheck values in logbook.
3. Take field measurements.	The following is a general summary for field measurement of pH and temperature: 1. Rinse beaker with sample water three times. 2. Rinse ATC pH probe with de-ionized water. 3. Fill beaker with sample water. 4. Turn on meter and immerse ATC pH probe in sample water. Stir sample for thorough mixing. Read and record temperature to the nearest 0.1 unit once pH and temperature readings have stabilized. 5. Rinse electrodes with de-ionized water and store in carrying case. <u>Note:</u> temperature may also be measured by placing the probe directly into the water body being tested. The probe must be moved slowly in a circular motion when measuring stagnant water.
Important information about meter.	1. Store meter in case during transport. 2. Check batteries before taking meter into the field. Carry spare batteries and de-ionized water for rinsing probe. 3. Inspect probe for damage or dirt. 4. Dust and wipe the meter with a damp cloth. If necessary, warm water or mild water based detergent can be used to clean the case. Immediately remove any spilled substance from the meter using the proper cleaning procedure for the type of spill. 5. If meter readings are erratic, replace the probe. If readings continue to be erratic, return the meter to factory for repair.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated water.	Testing sites, during temperature measurements.	Inadvertent exposure to contaminated water could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Personnel will wear nitrile gloves and safety glasses when taking measurements.
	Potential contact with pH buffer solutions.	Equipment calibration.	Inadvertent exposure to pH buffer solutions could lead to adverse health effects (e.g., irritation of eye, skin, and/or respiratory tract).	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and after calibrating equipment. Personnel will wear nitrile gloves and safety glasses when handling pH buffer solutions.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Bending, squatting, and kneeling.	During temperature measurements.	Bending, squatting, and kneeling during temperature measurements could result in muscle/back strains or other injuries.	Employees should stretch prior to starting work and they will take breaks when necessary.
	Drowning and/or entrapment hazards.	Bodies of water, during temperature measurements.	If employees need to stand in bodies of water to take measurements, they could be exposed to drowning and/or entrapment hazards from soft soils and/or sudden changes	If necessary, workers will use rods to test soil stability and/or depth of water as they walk to sample locations. In addition, workers may be required to wear life vests when crossing deeper bodies of water. When possible, workers will not enter the water body and take measurements from the bank.

			in depth of water.	
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Personnel will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Personnel will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Hypothermia/ frostbite.	Sites where air temperature is 35.6°F (2°C) or less.	Workers who become immersed in water or whose clothing becomes wet may be exposed to hypothermia and/or frostbite.	Employees will change clothing if it becomes wet. When applicable, employees will wear waders to prevent clothing from getting wet.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.

BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDS	pH 4, pH 7, and pH 10 buffer solutions. Additional Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	Map with site location and sample locations.
RELATED SOPs/PROCEDURES/ WORK PLANS	
TOOLS	pH field measurement meters, spare batteries for the pH field measurement meters, de-ionized water, pH 7 buffer solution, pH 4 buffer solution, pH 10 buffer solution, beaker, and field logbook.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**05/28/2015**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**05/28/2015**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for field measurements of dissolved oxygen.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Note	Pioneer owns and operates several brands and models of dissolved oxygen (DO) field measurement meters. All the units have automatic barometric pressure and salinity content compensation. User manuals for each meter are available and the specific directions for calibrating and measuring DO with that meter should be followed. The following is a general summary for field measurement of DO.
1. Calibrate the meter.	All field meters must be calibrated prior to use. Calibration shall be performed at a minimum of once per day for each day of instrument use. Calibration shall be performed prior to the first measurements of the day. Refer to the meter specific operating manual for calibration instructions. Listed below are general calibration requirements: 1. Inspect DO meter and probe for damage. If one of the YSI DO meters is to be used, inspect the probe for sufficient electrolyte and to determine if the oxygen sensor membrane is in good condition. Replace membrane, if torn or wrinkled. Inspect for air bubbles beneath the membrane. If bubbles are present, remove membrane and add electrolyte solution. Replace membrane so that air bubbles are absent. If the Thermo Scientific DO meters are used, check to make sure the RDO Optical Dissolved Oxygen probe has not exceeded its lifespan. 2. Turn the meter on and if needed place the meter in the DO measurement mode. Calibrate instrument as described in the meter specific operating manual. Unless specified in the Sampling and Analysis Plan (SAP) or work plan, calibration should be conducted in the % saturation mode. Replace batteries and clean probe, if meter does not calibrate properly. 3. With all of Pioneers DO meters, an air calibration is performed in water saturated air using the calibration/storage sleeve. To begin, check the sponge in the calibration sleeve and moisten the sponge with distilled water, if needed. Place 3-6 drops of water on the sponge and then allow any excess water to drain out of the chamber. The wet sponge creates a 100% water saturated air environment for the probe. This environment is ideal for DO calibration and for

	storage of the probe during transport and non-use. 4. Allow the probe and calibration standard (water saturated air) to reach equilibrium. 5. Calibrate the meter according to manufacturer's instructions. To accurately calibrate the YSI DO meters you will need to know the following information: • The approximate salinity of the water you will be analyzing. Fresh water has a salinity of approximately zero. Seawater has a salinity of approximately 35 parts per thousand (ppt). • For calibration in % saturation mode, the approximate altitude (in feet) of the region where you are located is required. This information can be obtained over the internet or from a topographic map. 6. Record the % saturation number displayed at the end of the automatic calibration.
2. Take measurements.	Field DO measurements for surface water may be made by direct submersion of the instrument probe into the sample stream. If flow is turbulent or shallow, or if direct immersion of the probe would risk damaging the probe, a grab sample can be collected and immediate measurement of the grab sample conducted. Field DO measurements of groundwater may be made by inserting the probe into a flow through device or by collection of a grab sample and immediate analysis of the grab sample in the field. Specific requirements may be listed in the SAP or work plan. The site-specific document may list the units that DO should be measured in (e.g., % saturation or mg/L). Refer to the meter-specific operating manual for measurement instructions. Listed below are general measurement instructions: 1. If the probe cannot be placed directly into the water being measured, rinse the decontaminated beaker with sample water three times. 2. Fill the beaker with the water to be measured. 3. Continuously stir or move the probe through the sample at a rate of about one foot per second. 4. Allow temperature and dissolved oxygen readings to stabilize. 5. Read and record the DO result in the field logbook or on a field data sheet making sure that the correct units are recorded (either % Sat or mg/L). Record the sample temperature to the nearest 0.1ºC from a pH meter, if available, after the temperature has equilibrated. 6. Spray the probe with de-ionized water and wipe clean before reinserting to calibration/storage sleeve. 7. Repeat the above steps for all samples.

	8. When all samples have been measured, store the electrode according to their specific user guides.
3. Maintenance of equipment.	1. Store meter in case during transport. 2. Check batteries before taking meter into the field. Carry spare batteries and de-ionized water for rinsing probe. 3. Inspect probe for damage or dirt. 4. Dust and wipe the meter with a damp cloth. If necessary, use warm water or mild water based detergent to clean the case. Immediately remove any spilled substance from the meter using the proper cleaning procedure for the type of spill. 5. If meter readings are erratic, replace the probe. If measurement readings continue to be erratic, return the meter to factory for repair.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated water.	Testing sites, during field measurements.	Inadvertent exposure to contaminated water could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Personnel will wear nitrile gloves and safety glasses when taking measurements.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Bending, squatting, and kneeling. Drowning and/or entrapment hazards.	During field measurements. Bodies of water, during field measurements.	Bending, squatting, and kneeling during field measurements could result in muscle/back strains or other injuries. If employees need to stand in bodies of water to take measurements, they could be exposed to drowning and/or entrapment hazards from soft soils and/or sudden changes in depth of water.	Employees should stretch prior to starting work and they will take breaks when necessary. If necessary, workers will use rods to test soil stability and/or depth of water as they walk to sample locations. In addition, personnel may be required to wear life vests when crossing deeper bodies of water. When possible, workers will not enter the water body and take measurements from the bank.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in	Personnel will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear

			falls and injuries.	muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Personnel will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Hypothermia/ frostbite.	Sites where air temperature is 35.6°F (2°C) or less.	Workers who become immersed in water or whose clothing becomes wet may be exposed to hypothermia and/or frostbite.	Employees will change clothing if it becomes wet. When applicable, employees will wear waders to prevent clothing from getting wet.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.

MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDS	Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	Map with site location and sample locations.
RELATED SOPs/PROCEDURES/ WORK PLANS	
TOOLS	Dissolved oxygen field measurement meter, de-ionized water, distilled water, decontaminated beaker, field logbook or field data sheet, and spare batteries for meter.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**12/17/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**12/17/2014**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for field turbidity measurements.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Note	The turbidity of the water pumped during well development and sampling or surface water testing will be measured using a portable turbidimeter. Record the general sampling information in the bound logbook, field data sheets or the well development data form, as appropriate. The turbidity measurement data for groundwater sampling will include, at a minimum, the well number, date and time, volume of water pumped, and the Nephelometric Turbidity Units (NTU) reading.
Equipment description	A HACH Model Portable Turbidity Meter (HACH Turbidimeter) operates on the nephelometric principle of turbidity measurement and meets EPA Method 180.1. The meter measures turbidity directly in NTU on a precalibrated meter scale. Calibration of the meter is based on an accepted primary standard of turbidity measurement and will be completed per the manufacturer's guidance.
1. Calibrate instrument.	All field meters must be calibrated prior to use. Perform calibration at a minimum of once per day for each day of instrument use. Perform calibration prior to the first measurements of the day. The HACH Turbidimeter calibration is accompanied with three standards provided in the meter kit by the manufacturer. 1. Place the meter on a flat steady surface. Do not hold the meter during operation. Turn on the meter and let it warm up. 2. Start the calibration process by pushing the "Calibration" key to enter the calibration mode and follow the instructions on the display. 3. Insert the calibration sample cell marked 20 NTU in the instrument cell compartment, close the lid and press "Read". <u>Note:</u> Before inserting the calibration cell, make sure that the sample cell is clean. Wipe the sample cell thoroughly with a lint free cloth. If needed, oil the sample cell with silicone oil. To ensure that the standard solutions are well-mixed, gently invert each standard before inserting into the meter. Insert so that the diamond or orientation mark aligns with the raised orientation mark in front of the cell

	compartment. 4. Record the result in the logbook. 5. Repeat steps 3 and 4 with the 100 NTU and 800 NTU calibration cells. Clean and gently invert each calibration cell prior to inserting in the meter. 6. Push "Done" to review the calibration details and record in logbook. 7. Push "Store" to save results. 8. The meter automatically goes into the "Verify Calibration" mode once the calibration sequence is complete. Insert the 20.0 NTU Verification Standard and close the lid. 9. Push "Read." The display shows "Stabilizing" and then shows the result and tolerance range. Record this information in the field logbook. 10. Push "Done" to return to the reading display. Repeat the calibration verification if the verification failed. These steps may vary from different models and manufactures. Always refer to manufacture's user manual.
2. Verify standards.	Verify manufacture's standards are reading accurately and record in logbook. The HACH Turbidimeter calibration is accompanied with four standards provided in the meter kit by the manufacturer: <0.1, 20, 100 and 800 NTU. HACH's accuracy is +/-2% of the reading plus stray light from 0-1,000 NTU (Formazin Turbidity Unit [FTU]). If turbidity meter is not a HACH Turbidimeter verify accuracy with manufacture's user manual. To verify the standards repeat steps 3 and 4 above with each of the four provided standards. Clean and gently invert each calibration cell prior to inserting in the meter.
3. Collect samples.	The HACH Turbidimeter requires collection of a sample for subsequent turbidity measurements. The sample may be collected using any clean container including a sample cell. Rinse sample cells three times with the water to be measured prior to filling the cell for measurement. Collect samples for field measurement purposes by direct submersion of the sample container into the flow whenever possible. For surface water, always collect samples upstream of sampling personnel and equipment, and with the sample container pointed upstream when the container is opened for sample collection. Take care not to sample water downstream of areas where sediments have been disturbed in any manner by field personnel.

	Collect samples from a location where the sample stream visually appears to be completely mixed. Ideally, this is at the center of the flow cross-section, but site conditions do not always allow this. The location should preferably be accessible by direct reach, or in the case of a receiving water body, via wading. Caution is required when wading, as flowing water provides more force than visually anticipated. If the center of the flow cannot be sampled by direct reach or by wading into the flow, use a sampling pole or other sampling device to reach the sampling location. Such devices typically involve a means to extend the reach of the sampler, with the sample bottle attached to the end of the device for filling at the desired location. For groundwater, fill the sample cells with sample water directly from the pump tubing during purging activities. Rinse the sample cell three times with purge water prior to sample collection.
4. Take turbidity measurements.	Always cap the sample cell prior to placing in the cell compartment to prevent spillage of the sample into the instrument. Use clean sample cells in good condition. Dirty, scratched or damaged cells can cause inaccurate readings. Make sure that cold samples do not "fog" the sample cell. 1. Collect a representative sample in a clean container. Fill a sample cell to the line (about 15 milliliter). Take care to handle the sample cell by the top. Cap the cell. 2. Wipe the cell with a soft, lint-free cloth to remove water spots and fingerprints. 3. Apply a thin film of silicone oil (provided in meter kit), if needed. Wipe with soft cloth (provided in meter kit) to obtain an even film over the entire surface. 4. Push the "Power" key to turn on the meter. Make sure that the meter is placed on a level, stationary surface during the measurement. Do not hold the meter in the hand during measurement. 5. Gently invert the sample cell to ensure mixing. Insert the sample cell in the instrument cell compartment so the diamond or orientation mark aligns with the raised orientation mark in front of the cell compartment. Close the lid. 6. Push the "Read" key. The display shows "Stabilizing" then displays the turbidity in NTU (FNU). 7. Record the value in the field logbook or on the field data form. These steps may vary for different models and manufactures. Always refer to the Turbidmeter manufacture's user manual. Repeat sample collection and measurement process as required in the sampling and analysis plan, work plan or the specific SOP.

	After use, rinse the sample cells with di-ionized water. Store the sample cells with caps on to prevent cells from drying. Do not air-dry the sample cells after use.
5. Store sample cells.	To properly store the sample cells: 1. Fill the sample cells with di-ionized water. 2. Cap and store the sample cells. 3. Wipe the outside of the sample cells dry with a soft cloth.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated water.	Testing sites, during sample collection and measurements.	Inadvertent exposure to contaminated water could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Personnel will wear nitrile gloves and safety glasses when collecting samples and taking measurements.
	20 NTU, 100 NTU, and 800 NTU verification standards.	During equipment calibration.	Employees can be exposed to verification standards via skin/eye contact and ingestion/ inhalation when calibrating equipment, which can result in skin/eye irritation and adverse health effects.	Employees will prevent skin/eye contact with verification standards and they will wear nitrile gloves and safety glasses when handling verification standards. Employees will practice proper personal hygiene – wash hands prior to eating/drinking, after equipment calibration, and when leaving the site.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Bending, squatting, and kneeling.	During sample collection and measurements.	Bending, squatting, and kneeling during sample collection and measurements could result in muscle/back strains or other injuries.	Employees should stretch prior to starting work and they will take breaks when necessary.
	Drowning and/or entrapment hazards.	Bodies of water, during sample collection.	If employees need to stand in bodies of water to collect samples, they could be exposed to	If necessary, workers will use rods to test soil stability and/or depth of water as they walk to sample locations. In addition, personnel may be required to wear life vests when crossing

			drowning and/or entrapment hazards from soft soils and/or sudden changes in depth of water.	deeper bodies of water. Caution is required when wading, as flowing water might provide more force than visually anticipated. When possible, workers will not enter the water body and collect samples from the bank.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Personnel will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Wear muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Personnel will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Hypothermia/ frostbite.	Sites where air temperature is 35.6°F (2°C) or less.	Workers who become immersed in water or whose clothing becomes wet may be exposed to hypothermia and/or frostbite.	Employees will change clothing if it becomes wet. When applicable, employees will wear waders to prevent clothing from getting wet.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.

RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Pinch points.	Well caps.	Personal injury could result from fingers getting pinched when opening/closing well caps.	Employees will wear work gloves when opening/closing well caps.
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDS	20 NTU, 100 NTU, and 800 NTU verification standards. Additional Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	Map with site location and sample locations.
RELATED SOPs/PROCEDURES/ WORK PLANS	
TOOLS	Turbidimeter and meter kit; bound logbook, field data sheets or well development data form; clear containers for sample collection; sampling pole or other sampling device (if the center of the flow cannot be sampled by direct reach or by wading into the flow); and de-ionized water.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**05/28/2015**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**05/28/2015**

APPROVALS/CONCURRENCE

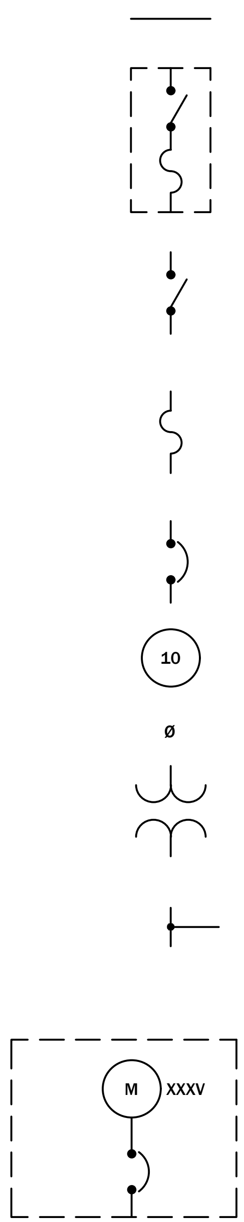
By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.

Revisions:

Revision	Description	Date

Appendix B
Electric One-Line Drawings

ELECTRICAL SYMBOL KEY



- ELECTRICAL FEEDER, I.E., CONDUIT AND WIRE
- FUSIBLE DISCONNECT SWITCH
- SWITCH, 1P-3P
- FUSE
- CIRCUIT BREAKER, 1P-3P
- MOTOR, 10HP, 480V, 3Ø
- PHASE
- TRANSFORMER
- ELECTRICAL FEEDER TAP NODE
- ELECTRICAL SERVICE METER MAIN

ABBREVIATIONS

3P, 2P - 3 OR 2 POLE SWITCHES OR CIRCUIT BREAKERS
A - AMPERES
AIC - ALLOWABLE INTERRUPTION CAPACITY
BPSOU - BUTTE PRIORITY SOILS OPERABLE UNIT
IOT—INTERNET OF THINGS
KVA - KILO-VOLT-AMPERES APPARENT POWER "KILO" IS THOUSAND
M - METER
NEC - NATIONAL ELECTRICAL CODE
NEMA - NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION
NFPA - NATIONAL FIRE PROTECTION ASSOCIATION
NWE - NORTHWESTERN ENERGY ELECTRIC UTILITY
R - RAINTITE
SBCCA - SILVER BOW CREEK CONSERVATION AREA
SCADA - SUPERVISORY CONTROL AND DATA ACQUISITION
TBD—TO BE DETERMINED
VFD - VARIABLE FREQUENCY DRIVE

DISPLAYED AS:
COORD SYS/ZONE: NA
DATUM: NA
UNITS: NA
SOURCE: PIONEER

SCALE IN FEET
0 N.T.S.

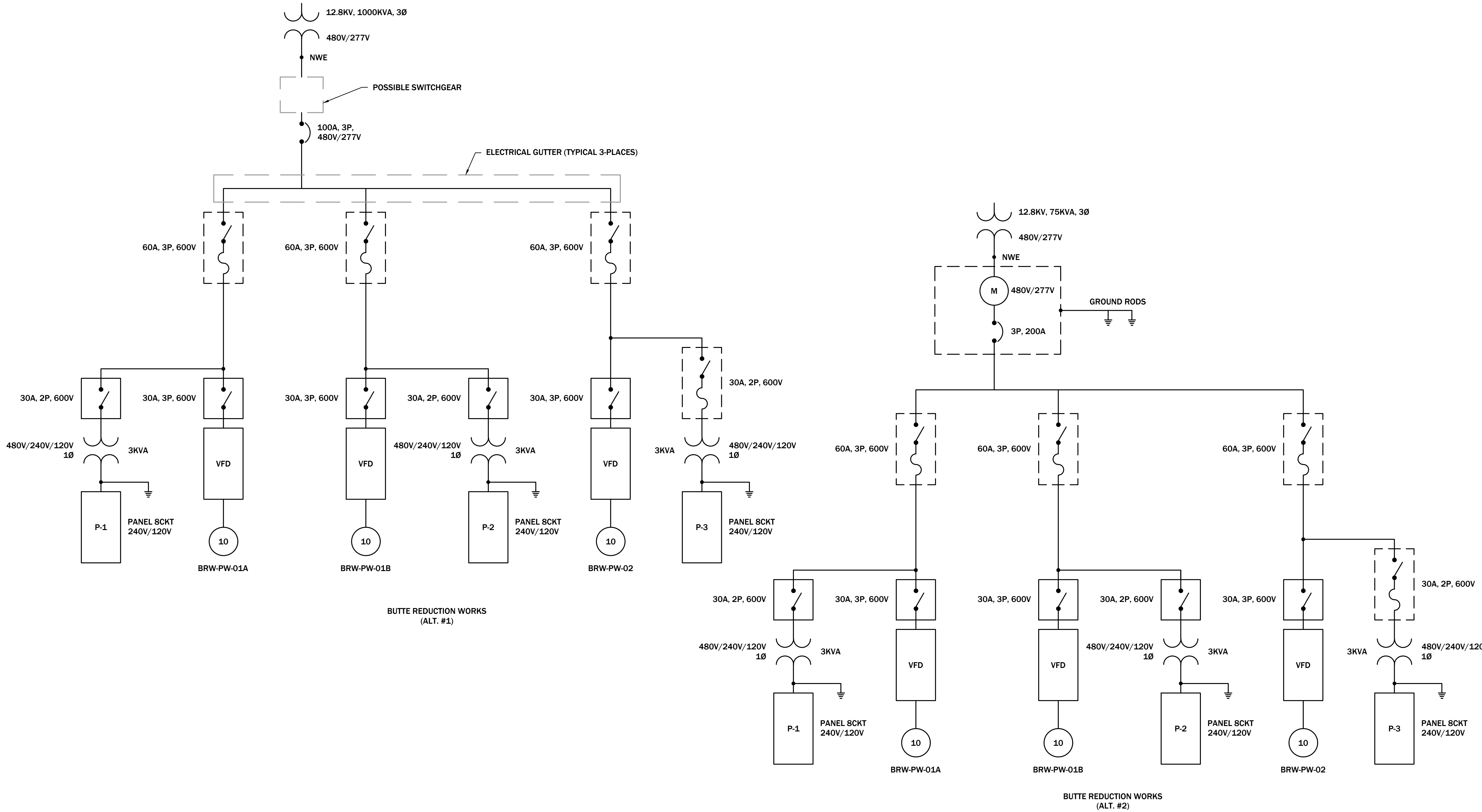
FIGURE E-1

PIONEER TECHNICAL SERVICES, INC.

1101 SOUTH MONTANA
BUTTE, MONTANA 59701
(406) 782-5177

ONE-LINE DIAGRAM LEGEND

DATE: 2/2021



DISPLAYED AS:
COORD SYS/ZONE: NA
DATUM: NA
UNITS: NA
SOURCE: PIONEER

SCALE IN FEET
0 N.T.S.

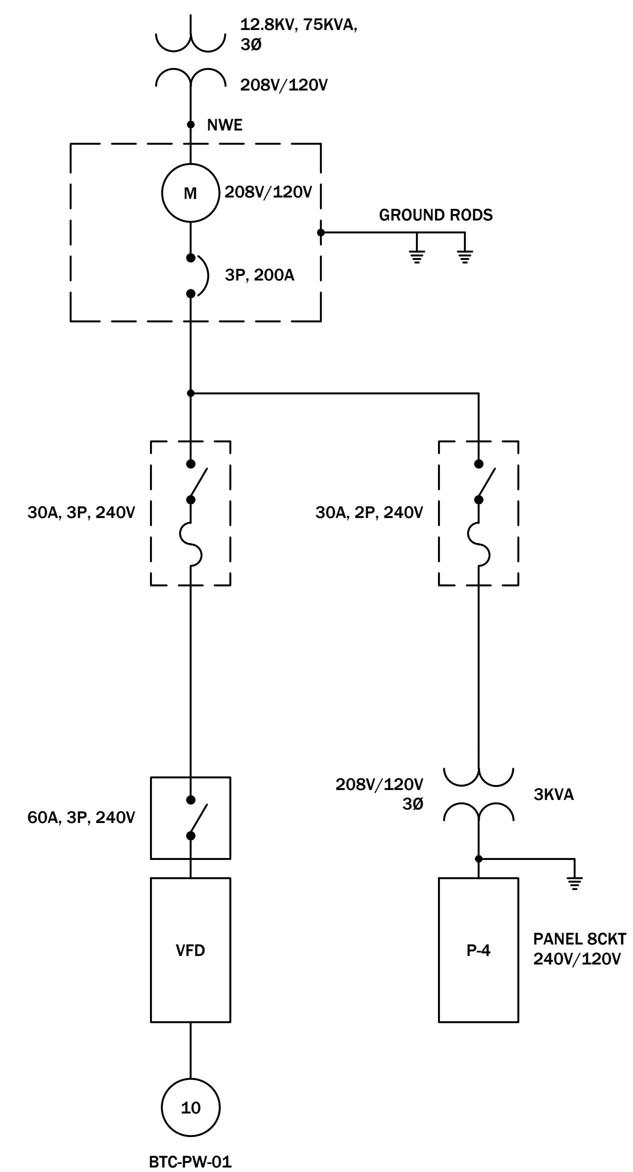
FIGURE E-2

PIONEER TECHNICAL SERVICES, INC.
1101 SOUTH MONTANA
BUTTE, MONTANA 59701
(406) 782-5177

BUTTE REDUCTION WORKS ONE-LINE DIAGRAM

DATE: 2/2021

2/17/2021 3:22:47 PM Z:\SHARED\ACTIVE PROJECTS\ARCO\BPSOU\GWRO\CADD\FIGURES\STRESSTESTONELINE_FIG_001_21.DWG



BLACKTAIL CREEK

DISPLAYED AS:
COORD SYS/ZONE: NA
DATUM: NA
UNITS: NA
SOURCE: PIONEER

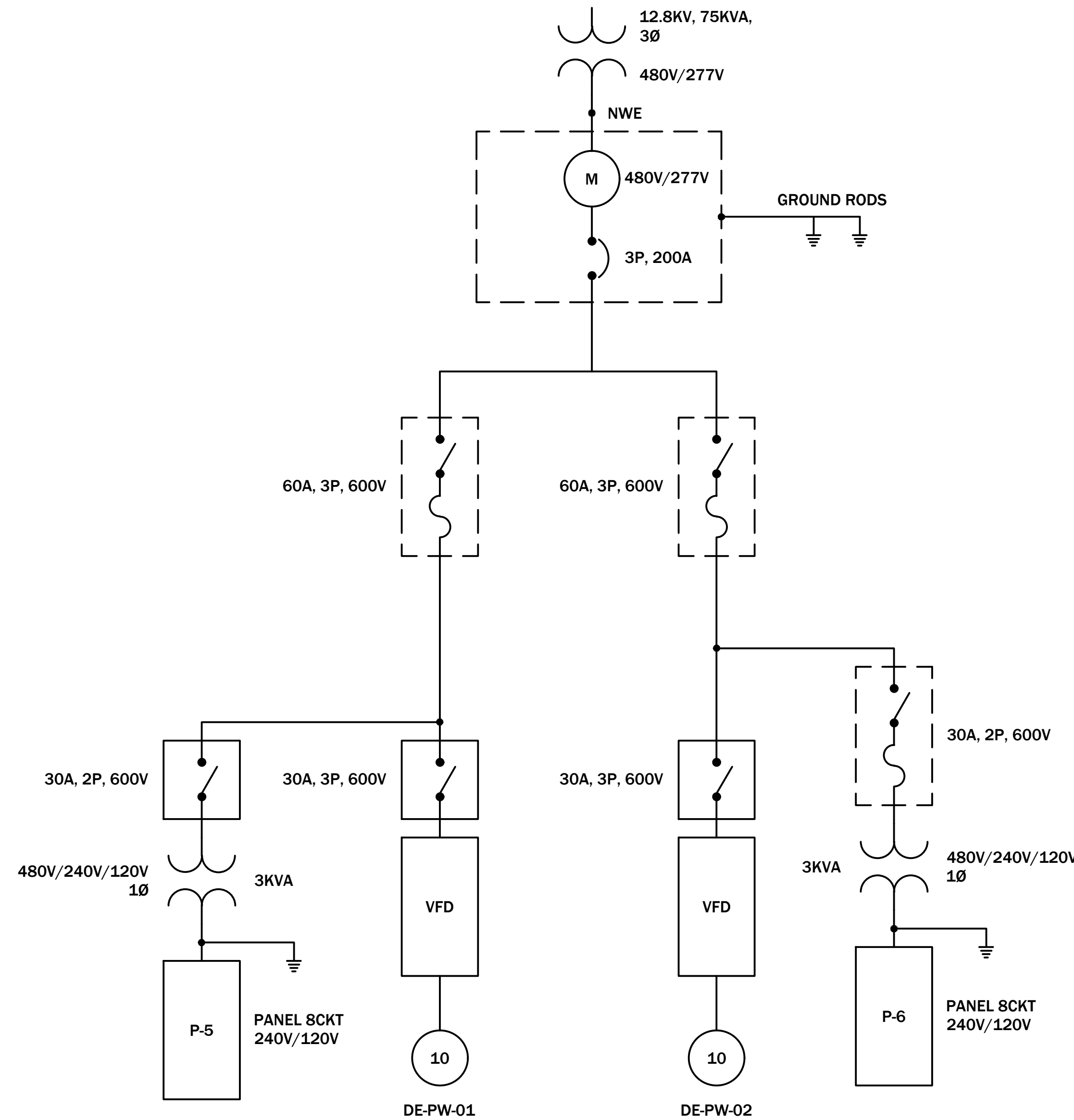
SCALE IN FEET
0 N.T.S.

FIGURE E-3

BLACKTAIL CREEK ONE-LINE DIAGRAM

PIONEER TECHNICAL SERVICES, INC.
1101 SOUTH MONTANA
BUTTE, MONTANA 59701
(406) 782-5177

DATE: 2/2021



DIGGINGS EAST

DISPLAYED AS:
COORD SYS/ZONE: NA
DATUM: NA
UNITS: NA
SOURCE: PIONEER

SCALE IN FEET
0 N.T.S.

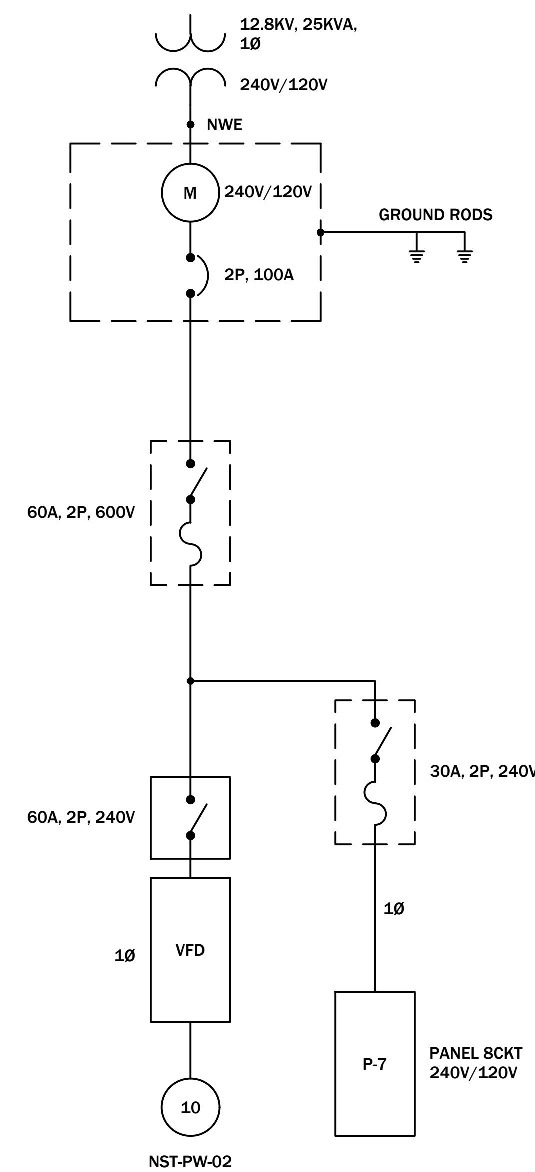
FIGURE E-4

PIONEER TECHNICAL SERVICES, INC.
1101 SOUTH MONTANA
BUTTE, MONTANA 59701
(406) 782-5177

DIGGINGS EAST ONE-LINE DIAGRAM

DATE: 2/2021

2/15/2021 1:48:16 PM Z:\SHARED\ACTIVE PROJECTS\ARCO\BPSOU\GWRO\CADD\FIGURES\STRESSTESTONELINE_FIG_001_21.DWG



NORTHSIDE TAILINGS

DISPLAYED AS:
COORD SYS/ZONE: NA
DATUM: NA
UNITS: NA
SOURCE: PIONEER

SCALE IN FEET
0 N.T.S.

FIGURE E-5

PIONEER TECHNICAL SERVICES, INC.
1101 SOUTH MONTANA
BUTTE, MONTANA 59701
(406) 782-5177

NORTHSIDE TAILINGS ONE-LINE DIAGRAM

DATE: 2/2021

Appendix C
List of BTL Alarms

PIONEER TECHNICAL SERVICES, INC.

ALARM LIST
Alarm acknowledgement must be performed locally at the site of the instrument. Alarms are PLC based, and callouts are performed through the RACO Catalyst alarm dialer located in the Operations Building.
Remote station data is transmitted to the Master Polling PLC located at the Operations Building.

DEVICE ID	ALARM ID	NAME	SET POINT	TIME DELAY	CAUSE TYPE = DIRECT ACTING, PLC BASED, OR ELECTRO-MECHANICAL BASED, AND DESCRIPTION: TYPE	DESCRIPTION	Display Status on HMI Panel: DISPLAY	Visual Control Panel Alarm: ACTIVATE	Auto Dialer Notification: ACTIVATE	Local Alarm: DISPLAY	Starts PLC Timer Interlock: ACTIVATE	Influent Pumps (D4-1 & 2) Shutdown: ACTIVATE	Lime Feed System Shutdown: ACTIVATE
LT-CAS-1000	LA-CAS-1000	T-LAO-3 Lime Silo Level; Alarm on low level	4 FT	10-min	PLC	Measurement < FT-starts 600 second PLC-based timer; < 4-FT >600= Priority 2 callout	X	X	X				
PS-CAS-1011	PA-CAS-1011	Pressure Switch; Alarm on low pressure	80 PSI	3-min	PLC	Measurement < 80PSI = Priority 1 callout	X	X	X	X			
HS-CAS-1030	ZA-CAS-1030	SC-LAO-1 Primary Screw Conveyor Run Status; Alarm at OFF status	OFF	3-min	PLC	OFF Status = 0; Priority 1 callout	X	X	X		X	X	X
HS-CAS-1031	ZA-CAS-1031	SC-LAO-2 Secondary Screw Conveyor Run Status; Alarm at OFF status	OFF	3-min	PLC	OFF Status = 0; Priority 1 callout	X	X	X		X	X	X
XE-CAS-1033	ZA-CAS-1033	Accurate Feeder Run Status; Alarm at OFF status	OFF	3-min	PLC	OFF Status = 0; Priority 1 callout	X	X	X	X	X	X	X
GEN-CAS-1035	ZA-CAS-1034	Detects CAS Building Generator Alarm Status; Alarm on Generator Fault	FAULT	3-min	DA	FAULT Status = 0; Priority 1 callout	X	X	X	X			
ZS-CAS-1036	ZS-CAS-1036	Detects CAS Building Transfer Switch Status; Alarm on Transfer	CLOSED	3-min	DA	CLOSED Status = 0; Priority 1 callout	X	X	X	X			
LT-CAS-1039	LA-CAS-1039	T-LAO-2 Slurry Tank 2 Level; Alarms when out of range	45, 12 INCHES	10-min	PLC	Measurement >45-IN or < 12-IN starts 600 second PLC based timer; >600-sec = Priority 2 callout	X	X	X				
FIT-CAS-1043	FA-CAS-1043	Measures Flow to T-LAO-2 Slurry Tank 2; Alarm on low flow	50 GPM	10-min	PLC	Measurement < 50GPM starts 600 second PLC based timer; <50GPM >600-sec = Priority 2 callout	X	X	X				
LT-CAS-1049	LA-CAS-1049	T-LAO-1 Slurry Tank 1 Level; Alarms when out of range	45, 12 INCHES	10-min	PLC	Measurement >45-IN or < 12-IN starts 600 second PLC based timer; >600-sec = Priority 2 callout	X	X	X				
FIT-CAS-1051	FA-CAS-1051	Measures Flow to T-LAO-1 Slurry Tank 1; Alarm on low flow	50 GPM	10-min	PLC	Measurement < 50GPM starts 600 second PLC based timer; <50GPM >600-sec = Priority 2 callout	X	X	X				
ZT-CAS-1052	ZSO-CAS-1052	GV-LAO-1052 State; Alarms when CLOSED	CLOSED	~	PLC	CLOSED Status = 0	X	X					
ZT-CAS-1053	ZSO-CAS-1053	GV-LAO-1053 State; Alarms when CLOSED	CLOSED	~	PLC	CLOSED Status = 0	X	X					
ZT-CAS-1054	ZSO-CAS-1054	GV-LAO-1054 State; Alarms when CLOSED	CLOSED	~	PLC	CLOSED Status = 0	X	X					
LT-CAS-1055	LA-CAS-1055	T-LAO-6 Distribution Tank Level; Alarms when out of range	4, 30 INCHES	10-min	PLC	Measurement > 30-IN or < 4-IN starts 600 second PLC based timer; >600-sec = Priority 2 callout	X	X	X				
ZT-CAS-1056	ZSO-CAS-1056	GV-LAO-1056 State; Alarms when CLOSED	CLOSED	~	PLC	CLOSED Status = 0	X	X					
ZT-CAS-1057	ZSO-CAS-1057	GV-LAO-1057 State; Alarms when CLOSED	CLOSED	~	PLC	CLOSED Status = 0	X	X					
ZT-CAS-1058	ZSO-CAS-1058	GV-LAO-1058 State; Alarms when CLOSED	CLOSED	~	PLC	CLOSED Status = 0	X	X					
FIT-CAS-1059	FA-CAS-1059	Measure Influent Flow to CAS; Interlock with lime feed system	700 GPM	3-min	PLC	Measurement < 700GPM starts 180 second PLC based timer; <700GPM >180-sec, IPS & LFS shutdown, Priority 1 callout.	X	X	X		X	X	X
AIT-CAS-1060	AA-CAS-1060	Flow from T-LAO-1 Slurry Tank 1 Conductivity; Alarms when out of range	2500 Us	10-min	PLC	Measurement < 2500 uS starts 600 second PLC based timer; <700GPM >180-sec, IPS & LFS shutdown, Priority 2 callout	X	X					
AIT-CAS-1061	AA-CAS-1061	Flow from T-LAO-2 Slurry Tank 2 Conductivity; Alarms when out of range	2500 Us	10-min	PLC	Measurement < 2500 uS starts 600 second PLC based timer; <700GPM >180-sec, IPS & LFS shutdown, Priority 2 callout	X	X					
ZA-CAS-1062	ZA-CAS-1062	Detects power surge at CASB; Alarms on surge	FAULT	~	PLC	FAULT Status = 0, NORMAL Status = 1	X	X					
ZA-CAS-1063	ZA-CAS-1063	Monitors power at CASB; Alarms on loss of power	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priorty 1 callout	X	X	X				
ESS-CAS-1064	ZA-CAS-1064	Emergency Stop Button, mounted directly to the master control PLC panel	STOP	~	E-MECH	Local hardwired emergency shudown button	X	X	X	X		X	X
ZA-CAS-1065	ZA-CAS-1065	Detects communication failure at CASB; Alarms on loss of communication	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priorty 1 callout	X	X	X				
LT-LAO-2000	LA-LAO-2000	Measures Lagoon A1 Level (shown on screen as elevation); Alarms when out of range	5422, 5429.85 FT	~	PLC	Measurement > 5429.85-FT or < 5422-FT starts 600 second PLC based timer	X	X					
LT-LAO-2003	LA-LAO-2003	Measures Lagoon A2 Level (shown on screen as elevation); Alarms when out of range	5420, 5428 FT	~	PLC	Measurement > 5428-FT or < 5420-FT starts 600 second PLC based timer	X	X					
LT-LAO-2006	LA-LAO-2006	Measures Lagoon A3 Level (shown on screen as elevation); Alarms when out of range	5420, 5428.83 FT	~	PLC	Measurement > 5428.83-FT or < 5420-FT starts 600 second PLC based timer	X	X					
LT-LAO-2015	LA-LAO-2015	Measures Lagoon B1 Level (shown on screen as elevation); Alarms when out of range	5422, 5430.35 FT	~	PLC	Measurement > 5430.35-FT or < 5422-FT starts 600 second PLC based timer	X	X					
LT-LAO-2017	LA-LAO-2017	Measures Lagoon B3 Level (shown on screen as elevation); Alarms when out of range	5422, 5429.11 FT	~	PLC	Measurement > 5429.11-FT or < 5422-FT starts 600 second PLC based timer	X	X					
LT-LAO-2021	LA-LAO-2021	Measures Lagoon C1 Level (shown on screen as elevation); Alarms when out of range	5422, 5430 FT	~	PLC	Measurement > 5430-FT or < 5422-FT starts 600 second PLC based timer	X	X					
LT-LAO-2025	LA-LAO-2025	Measures Lagoon C3 Level (shown on screen as elevation); Alarms when out of range	5420, 5428.29 FT	~	PLC	Measurement > 5428.29-FT or < 5422-FT starts 600 second PLC based timer	X	X					
LT-LAO-2009	LA-LAO-2009	Measures Lagoon D2 Level (shown on screen as elevation); Alarms when out of range	5418, 5424 FT	10-min	PLC	Measurement > 5424-FT or < 5418-FT starts 600 second PLC based timer; >600-sec = Priority 2 callout	X	X	X				
LT-LAO-2011	LA-LAO-2011	Measures Lagoon D3 Level (shown on screen as elevation); Alarms when out of range	5418, 5424 FT	10-min	PLC	Measurement > 5424-FT or < 5418-FT starts 600 second PLC based timer; >600-sec = Priority 2 callout	X	X	X				
LT-LAO-2013	LA-LAO-2013	Measures Lagoon D4 Level (shown on screen as elevation); Alarms when out of range	5418.35, 5419 FT	10-min	PLC	Measurement > 5419-FT or < 5418.35-FT starts 600 second PLC based timer; >600-sec = Priority 2 callout	X	X	X				
ZA-LAO-2030	ZA-LAO-2030	Detects power surge at OA1; Alarms on surge	FAULT	~	PLC	FAULT Status = 0, NORMAL Status = 1	X	X					
ZA-LAO-2031	ZA-LAO-2031	Monitors power at OA1, Alarms on loss of power	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priorty 1 callout	X	X	X				
ZA-LAO-2032	ZA-LAO-2032	Detects communication failure at OA1; Alarms on loss of communication	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priorty 1 callout	X	X	X				
ZA-LAO-2060	ZA-LAO-2060	Detects power surge at OA2; Alarms on surge	FAULT	~	PLC	FAULT Status = 0, NORMAL Status = 1	X	X					
ZA-LAO-2061	ZA-LAO-2061	Monitors power at OA2, Alarms on loss of power	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priorty 1 callout	X	X	X				
ZA-LAO-2062	ZA-LAO-2062	Detects communication failure at OA2; Alarms on loss of communication	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priorty 1 callout	X	X	X				
LT-IPS-3001	LA-IPS-3001	Detects T-IPS-D4-1 Vault Level; Alarms when out of range	5418.35, 5418.8, 5419 FT	10-min	PLC	Measurement >5418.8-FT or < 5418.35-FT starts 600 second PLC based timer; >600-sec ALARM; Priority 2 callout	X	X	X				
ZX-IPS-3002	ZA-IPS-3002	Detects P-IPS-D4-1 Pump Run Status; Alarms on State - OFF	OFF	3-min	PLC	OFF Status = 0, NORMAL RUN Status = 1; Priority 1 callout	X	X	X		X	X	X
FIT-IPS-3005	FA-IPS-3005	Detects P-IPS-D4-1 Pump Flow; Alarms on LO Flow	700 GPM	3-min	PLC	Measurement < 700GPM starts 180 second PLC based timer; <700GPM >180-sec, Priority 1 callout	X	X	X				
LT-IPS-3007	LA-IPS-3007	Detects T-IPS-D4-2 Vault Level; Alarms when out of range	5418.35, 5418.8, 5419 FT	10-min	PLC	Measurement >5418.8-FT or < 5418.35-FT starts 600 second PLC based timer; >600-sec ALARM; Priority 2 callout	X	X	X				
ZX-IPS-3008	ZA-IPS-3008	Detects P-IPS-D4-2 Pump Run Status; Alarms on State - OFF	OFF	3-min	PLC	OFF Status = 0, NORMAL RUN Status = 1; Priority 1 callout	X	X	X		X	X	X
FIT-IPS-3011	FA-IPS-3011	Detects P-IPS-D4-2 Pump Flow; Alarms on LO Flow	700 GPM	3-min	PLC	Measurement < 700GPM starts 180 second PLC based timer; <700GPM >180-sec, Priority 1 callout	X	X	X				
PS-IPS-3013	PA-IPS-3013	Pressure Switch for P-IPS-D4-1; Alarm on high pressure	60 PSI	3-min	PLC	Measurement > 60-PSI = Priority 1 callout	X	X	X				
PS-IPS-3014	PA-IPS-3014	Pressure Switch for P-IPS-D4-2; Alarm on high pressure	60 PSI	3-min	PLC	Measurement > 60-PSI = Priority 1 callout	X	X	X				
GEN-IPS-3015	ZA-IPS-3015	Detects IPS Building Generator Alarm Status; Alarm on Generator Fault	ON	3-min	DA	OFF Status = 0, NORMAL RUN Status = 1; Priority 1 callout	X	X	X	X			
ZS-IPS-3017	ZS-IPS-3017	Detects IPS Building Transfer Switch Status; Alarm on Transfer	CLOSED	3-min	DA	OFF Status = 0, NORMAL RUN Status = 1; Priority 1 callout	X	X	X	X			
ZA-IPS-3018	ZA-IPS-3018	Detects power surge at IPS; Alarms on surge	FAULT	~	PLC	FAULT Status = 0, NORMAL Status = 1	X	X					
ZA-IPS-3019	ZA-IPS-3019	Monitors power at IPS; Alarms on loss of power	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priorty 1 callout	X	X	X				
ZA-IPS-3020	ZA-IPS-3020	Detects communication failure at IPS; Alarms on loss of communication	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priorty 1 callout	X	X	X				

PIONEER TECHNICAL SERVICES, INC.

ALARM LIST

Alarm acknowledgement must be performed locally at the site of the instrument. Alarms are PLC based, and callouts are performed through the RACO Catalyst alarm dialer located in the Operations Building.
Remote station data is transmitted to the Master Polling PLC located at the Operations Building.

DEVICE ID	ALARM ID	NAME	SET POINT	TIME DELAY	CAUSE TYPE = DIRECT ACTING, PLC BASED, OR ELECTRO-MECHANICAL BASED, AND DESCRIPTION TYPE	DESCRIPTION	Display Status on HMI Panel DISPLAY	Visual Control Panel Alarm ACTIVATE	Auto Dialer Notification ACTIVATE	Local Alarm DISPLAY	Starts PLC Timer Interlock ACTIVATE	Influent Pumps (D4-1 & 2) Shutdown ACTIVATE	Lime Feed System Shutdown ACTIVATE
FIT-ASB-4000	FA-ASB-4000	Measures Effluent Discharge Flow to Silver Bow Creek; Alarm on low flow	400 GPM	3-min	PLC	Measurement < 400GPM starts 180 second PLC based timer; <400GPM >180-sec, Priority 1 callout	X	X	X				
ZI-ASB-4002	ZA-ASB-4002	Detects P-ASB Pump Run Status; Alarms on State - OFF	OFF	10-min	PLC	OFF Status = 0, NORMAL RUN Status = 1	X	X					
AIT-ASB-4005	AA-ASB-4005	Measures Effluent Discharge pH; Alarms when out of range	9.5, 8.9 pH	3-min	PLC	Measurement > 9.5 or < 8.9 starts 180 second PLC timer; Priority 1 callout							
ZA-ASB-4007	ZA-ASB-4007	Detects power surge at ASB; Alarms on surge	FAULT	~	PLC	FAULT Status = 0, NORMAL Status = 1	X	X					
ZA-ASB-4008	ZA-ASB-4008	Monitors power at ASB; Alarms on loss of power	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priority 1 callout	X	X	X				
ZA-ASB-4009	ZA-ASB-4009	Detects communication failure at ASB; Alarms on loss of communication	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priorty 1 callout	X	X	X				
AIT-WCP-5000	AA-WCP-5000	H2S Sensor Measures H2S level at WCP-1 Building; Alarms on High level	10 PPM	3-min	PLC	Measurement >10ppm, field instrument audible and visual alarm, & Priority 1 callout	X	X	X	X			
LT-WCP-5001A	LA-WCP-5001A	Measures WCP-1 Well (BMF96-1D) Level; Alarms on HI Level	5,430 FT	10-min	PLC	Measurement > 5430 FT > 600 seconds = Priority 2 callout	X	X	X				
LT-WCP-5001B	LA-WCP-5001B	Measures WCP-1 Well (BMF96-1D) Level; Alarms on HI Level	5,430 FT	10-min	PLC	Measurement > 5430 FT > 600 seconds = Priority 2 callout	X	X	X				
ZA-WCP-5005	ZA-WCP-5005	Detects P-WCP-1 Pump Fault; Alarm on Fault	ON	3-min	PLC	ON Status = 0, NORMAL OFF Status = 1, Priority 1 callout	X	X	X				
FIT-WCP-5008	FA-WCP-5008	Measures WCP-1 Flow; Alarms on LO Flow	70 GPM	10-min	PLC	Measurement < 70GPM starts 180 second PLC based timer; <70GPM >180-sec = Priority 2 callout	X	X	X				
ZA-WCP-5010	ZA-WCP-5010	Detects WCP-1 Building Generator Alarm Status; Alarm on Generator Fault	ON	3-min	DA	ON Status = 0, NORMAL OFF Status = 1, Priority 1 callout	X	X	X	X			
ZS-WCP-5012	ZS-WCP-5012	Detects WCP-1 Building Transfer Switch Status; Alarm on Transfer	CLOSED	3-min	DA	ON Status = 0, NORMAL OFF Status = 1, Priority 1 callout	X	X	X	X			
ZA-WCP-5014	ZA-WCP-5014	Detects power surge at WCP-1; Alarms on surge	FAULT	~	PLC	FAULT Status = 0, Normal Status = 1	X	X					
ZA-WCP-5015	ZA-WCP-5015	Monitors power at WCP-1; Alarms on loss of power	FAULT	3-min	PLC	FAULT Status = 0, Normal Status = 1; Priority 1 callout	X	X	X	X			
ZA-WCP-5016	ZA-WCP-5016	Detects communication failure at WCP-1; Alarms on loss of communication	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priorty 1 callout	X	X	X				
LT-MSD-6002A	LA-MSD-6002A	Measures VAULT-MSD-1 Level; Alarms on HI level	48, 38 INCHES	3-min	PLC	Measurement < 38 IN or > 48 IN = Priority 1 callout	X	X	X				
LT-MSD-6002B	LA-MSD-6002B	Measures VAULT-MSD-1 Level; Alarms on HI level	48, 38 INCHES	3-min	PLC	Measurement < 38 IN or > 48 IN = Priority 1 callout	X	X	X				
ZA-MSD-6006	ZA-MSD-6006	Detects P-MSD-S Pump Run Status; Alarms on State - OFF	OFF	3-min	PLC	OFF Status = 0, NORMAL RUN Status = 1; Priority 1 callout	X	X	X		X	X	X
ZA-MSD-6007	ZA-MSD-6007	Detects P-MSD-S Pump Fault; Alarm on Fault	ON	3-min	PLC	ON Status = 0, NORMAL OFF Status = 1, Priority 1 callout	X	X	X	X			
ZA-MSD-6009	ZA-MSD-6009	Detects P-MSD-N Pump Run Status; Alarms on State - OFF	OFF	3-min	PLC	OFF Status = 0, NORMAL RUN Status = 1; Priority 1 callout	X	X	X		X	X	X
ZA-MSD-6010	ZA-MSD-6010	Detects P-MSD-N Pump Fault; Alarm on Fault	ON	3-min	PLC	ON Status = 0, NORMAL OFF Status = 1, Priority 1 callout	X	X	X	X			
ZA-MSD-6015	ZA-MSD-6015	Detects P-MSD-TEMP Pump Status change; Alarms on OFF status	OFF	3-min	PLC	OFF Status = 0, NORMAL ON Status = 1, Priority 1 callout	X	X	X	X			
FIT-MSD-6019	FA-MSD-6019	Measures MSD Effluent Flow; Alarms on LO flow	100, 900 GPM	3-min	PLC	Measurement < 100-GPM or > 900-GPM = Priority 1 callout	X	X	X	X			
FIT-BRW-6025	FA-BRW-6025	Measures MSD Effluent Flow; Alarms on LO flow	100, 900 GPM	3-min	PLC	Measurement < 100-GPM or > 900-GPM = Priority 1 callout	X	X	X				
ZA-MSD-6035	ZA-MSD-6035	Detects MSD Building Generator Alarm Status; Alarm on Generator Fault	FAULT	3-min	DA	FAULT Status = 0, NORMAL Status = 1; Priority 1 callout	X	X	X	X			
ZS-MSD-6037	ZS-MSD-6037	Detects MSD Building Transfer Switch Status; Alarm on Transfer	CLOSED	3-min	DA	FAULT Status = 0, NORMAL Status = 1; Priority 1 callout	X	X	X	X			
ZA-MSD-6039	ZA-MSD-6039	Detects power surge at MSD; Alarms on surge	FAULT	~	PLC	FAULT Status = 0, NORMAL Status = 1	X	X					
ZA-MSD-6040	ZA-MSD-6040	Monitors power at MSD; Alarms on loss of power	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priority 1 callout	X	X	X				
ZA-MSD-6041	ZA-MSD-6041	Detects communication failure at MSD; Alarms on loss of communication	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priorty 1 callout	X	X	X				
ZT-BRW-7007	ZSO-BRW-7007	GV-BRW-7007 State; Alarms when CLOSED	CLOSED	~	PLC	CLOSED Status = 0	X	X					
ZT-BRW-7008	ZSO-BRW-7008	GV-BRW-7008 State; Alarms when CLOSED	CLOSED	~	PLC	CLOSED Status = 0	X	X					
LT-BRW-7009	LA-BRW-7009	Measures DB-BRW-1 Drying Bed Level (shown on screen as elevation); Alarms on HI	3, 4.5 FT	10-min	PLC	Measurement < 3-FT or < 4.5-FT	X	X					
ZT-BRW-7011	ZSO-BRW-7011	GV-BRW-7011 State; Alarms when CLOSED	CLOSED	~	PLC	CLOSED Status = 0	X	X					
ZT-BRW-7012	ZSO-BRW-7012	GV-BRW-7012 State; Alarms when CLOSED	CLOSED	~	PLC	CLOSED Status = 0	X	X					
LT-BRW-7013	LA-BRW-7013	Measures DB-BRW-2 Drying Bed Level (shown on screen as elevation); Alarms on HI	3, 4.5 FT	10-min	PLC	Measurement < 3-FT or < 4.5-FT	X	X					
LT-BRW-7015	LA-BRW-7015	Measures DB-BRW-3 Drying Bed Level (shown on screen as elevation); Alarms on HI	3, 4.5 FT	10-min	PLC	Measurement < 3-FT or < 4.5-FT	X	X					
ZA-BRW-7017	ZA-BRW-7017	Detects power surge at BRW; Alarms on surge	FAULT	~	PLC	FAULT Status = 0, NORMAL Status = 1	X	X					
ZA-BRW-7018	ZA-BRW-7018	Monitors power at BRW; Alarms on loss of power	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priority 1 callout	X	X	X				
ZA-BRW-7019	ZA-BRW-7019	Detects communication failure at BRW; Alarms on loss of communication	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priorty 1 callout	X	X	X				
ZT-LAO-7019	ZSO-LAO-7019	GV-LAO-7019 State; Alarms when OPEN	OPEN	~	PLC	OPEN Status = 0	X	X					
ZA-BRW-7030	ZA-BRW-7030	Detects power surge at Drying Beds; Alarms on surge	FAULT	~	PLC	FAULT Status = 0, NORMAL Status = 1							
ZA-BRW-7031	ZA-BRW-7031	Monitors power at Drying Beds; Alarms on loss of power	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priority 1 callout							
ZA-BRW-7032	ZA-BRW-7032	Detects communication failure at Drying Beds; Alarms on loss of communication	FAULT	3-min	PLC	FAULT Status = 0, NORMAL Status = 1; Priorty 1 callout	X	X	X				

Appendix D
Sampling Logic for PCP/TPH Monitoring

Appendix D.1: Stress Test Hydrocarbon Logic

Objective: Lay out a logical sequence for detecting hydrocarbons in the production water from BRW pumping wells during the stress test. During the Phase II pumping tests, no hydrocarbon species were detected above discharge criteria thresholds. Hydrocarbon sampling will continue to be performed during extended pumping for the stress test to ensure detectable hydrocarbon concentrations do not enter the BTL system. Increasing concentrations of total petroleum hydrocarbons in production water may correlate to increasing concentrations of criteria analytes in BTL effluent (e.g., benzene). Analytical sampling to confirm field-detected concentrations will be collected from the mixed production water.

Table 1: Hydrocarbon Sampling Logic

Days of Pumping	Frequency	If Mixed Production Water Sample Is…	Then…	Logic
0	**Once**	Non-detect	Note in logbook and continue pumping	If no hydrocarbons are detected in the field kit, the risk of hydrocarbon contamination reaching BTL is low.
		Detect >= 0.1 ppm	Note in logbook and continue pumping	If hydrocarbons are detected below the 1.0 ppm concentration, it is unlikely hydrocarbon species are near discharge standards, but more frequent monitoring will continue to observe concentration trends.
		Detect > 1.0 ppm	Note in logbook and collect independent grab samples from each well to confirm results and distinguish source.	Hydrocarbon concentrations may decrease over time, and detectable concentrations may be the result of measurement error. If individual sample results do not confirm the initial results, the QAO will be notified to resolve potential testing issues.
0.208	**Once (30 minutes after pumping begins)**	Non-detect	Note in logbook and continue pumping	If no hydrocarbons are detected in the field kit, the risk of hydrocarbon contamination reaching BTL is low, and field testing will continue once per day.
		Detect >= 0.1 ppm	Note in logbook and continue pumping; increase field sample collection to twice per day. If concentrations increase to >1.0 ppm, follow procedure below. If concentrations decrease below detection, continue pumping and reduce field testing to once per day.	Detection between 0.1 and 1.0 ppm warrants frequent field testing to determine whether hydrocarbon concentrations will continue to increase. If concentrations decrease below detection, testing may be reduced to once per day.
		Detect >1.0 ppm	Note in logbook and collect field grab sample from each well independently to confirm result. Analytical grab sample (and QA samples) will be collected if TPH detected at start of pumping and at 30 minutes from one or more wells exhibiting field detection, and CPM and QAO notified. Field sampling will continue twice per day until field kit non-detect; continued detection above the threshold will result in cessation of pumping. Analytical results above criteria will result in cessation of pumping.	Results greater than 1.0 ppm in the field sample may indicate failure to meet discharge criteria in one or more hydrocarbon species. Analytical water quality samples will be collected and rush analyzed to confirm field results, and the CPM and QAO may make the decision to cease pumping until a corrective action is in place at any time after hydrocarbons are detected.
1-5	**If non-detect, once per day**	Non-detect	Note in logbook and continue pumping	Daily samples should confirm the lack of detectable hydrocarbons in the production water. After 5 days of pumping, the aquifer should reach steady-state conditions, sampling frequency will be decreased with continuing TPH non-detection.
		Detect >= 0.1 ppm	Note in logbook and continue pumping; increase field sample collection to twice per day. If concentrations increase to >1.0 ppm, follow procedure below. If concentrations decrease below detection, continue pumping and reduce field testing to once per day.	Detection between 0.1 and 1.0 ppm warrants frequent field testing to determine whether hydrocarbon concentrations will continue to increase. If concentrations decrease below detection, testing may be reduced to once per day.
		Detect >1.0 ppm	If the first detection >1.0 ppm occurs after 1 or more days, note result in logbook and collect field grab sample from each well independently to confirm result. Analytical grab sample will be collected from one or more wells showing detection above this threshold, and the CPM and QAO notified. Field testing will continue twice per day; continued field detection or analytical results above this threshold will result in cessation of pumping.	During this phase of pumping, the aquifer is expected to exhibit non-steady behavior, and daily testing will ensure any changes in hydrocarbon concentrations are detected. If a detection occurs above 1.0 ppm, an analytical grab sample will be collected and more frequent field testing will commence until non-detection or the decision to cease pumping.
6 to End of Pumping	**If non-detect, once per week**	Non-detect	Note in logbook and continue pumping	Continued non-detects after 5 days should indicate the lack of detectable hydrocarbons in the source wells. Weekly check samples will be continued through the duration of the test for continued monitoring.
		Detect >= 0.1 ppm	Note in logbook and continue pumping; increase field sample collection to once per day. If concentrations increase to >1.0 ppm, follow procedure below. If concentrations decrease below detection, continue pumping and reduce field testing to once per day. If daily samples are non-detect for two consecutive days, field testing will be reduced to once per week.	Detection between 0.1 and 1.0 ppm warrants frequent field testing to determine whether hydrocarbon concentrations will continue to increase. If concentrations decrease below detection for two consecutive days, testing may be again reduced to once per week.
		Detect >1.0 ppm	If the first detection >1.0 ppm occurs after 5 or more days, note result in logbook and collect field grab sample from each well independently to confirm result. Analytical grab samples will be collected from one or more wells showing detection above this threshold, and the CPM and QAO notified. Field testing will continue daily until concentrations decrease; continued field detection or analytical results above this threshold will result in cessation of pumping.	During this phase of pumping, steady state conditions are expected. If hydrocarbons have not been detected in mixed production water after 5 days, field sampling frequency will be reduced to once per week. A detection above 1.0 ppm in any of the weekly samples will result in collection of analytical grab samples and increased field sample frequency until concentrations decrease below detection or until continued detection of elevated concentrations results in cessation of pumping.

Laboratory Samples

Type	Preservation	Purpose	Frequency
Hydrocarbon laboratory sample	Unfiltered, see table.	Confirm field kit accuracy	once every 20 field test events
Field Duplicate		Verify sampling procedures	1 per 20 samples
Equipment blank		Verify equipment decontamination procedures	1 per 20 samples, as needed.
Field Blank		Verify DI water concentration	1 per 20 samples, as needed.

Company	Sample Group	Analyte	Analytical Method	CRQL	Holding Time	Container Size	Preservation[1]	Locations
Eurofins TestAmerica or equivalent	7	Volatile Petroleum Hydrocarbons (VPH)	MAVPH (Rev 1.1)	Analyte Specific - Meets DEQ-7 Required Reporting Limit and/or DEQ Risk-Based Screening Level where applicable.	14 Days	3--- 40-mL clear glass VOA vials	Unfiltered, acidified with HCl.	*Confirmation samples per Appendix D:* BRW-PW-01A, PRW-PW-01B. BRW-PW-02
		EPH Fractionation with Polycyclic Aromatic Hydrocarbons (PAHs)	Montana Method EPH (PAHs: 8270C or 8270D)			2--- 1-L amber glass	Unfiltered, acidified with H2SO4.	
		Lead Scavengers (1, 2 dichloroethane and 1, 2 dibromoetheane)	EPA 8011, EPA 8260B			6--- 40-mL clear glass VOA vials	Unfiltered, acidified with HCl.	

TECHNICAL MEMORANDUM

BTL Stress Test Early Detection Network Sampling Logic

Date:	5/4/2021	**Rev or Mod #:**	01
To:	Mike Borduin		
From:	Ross Monasmith		

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1 INTRODUCTION

The Butte Treatment Lagoon (BTL) Stress Test (Stress Test) will involve pumping water from up to three pumping wells in the Butte Reduction Works (BRW) Site area and routing this water to BTL for treatment. The potential adverse migration of pentachlorophenol (PCP), polychlorinated biphenyl (PCB), and variants of dioxin (congeners) into the BRW Site and/or Lower Area One (LAO) from the adjacent Montana Pole and Treating Plant (MPTP) (a National Priorities List Site) and NorthWestern Energy (NWE) property will be monitored during the Stress Test. It may also be advantageous to monitor, and potentially limit, the extent of groundwater drawdown caused by pumping in the BRW area. Before an early detection network can be effectively defined, baseline sampling in the area will be completed. Results from the baseline monitoring will be used to identify an appropriate monitoring network to be employed during the Stress Test and future construction dewatering efforts at the BRW Site.

Groundwater quality samples were collected during the BRW Phase II Site Investigation (including during the BRW pumping tests; Atlantic Richfield, 2021) and analyzed for the presence of PCP, PCB, and one variant of dioxin (2,3,7,8-tetrachlorodibenzo-p-dioxin [TCDD]). These chemicals were not detected at concentrations above the method detection limit (MDL) in the analytical samples collected during the BRW Phase II pumping tests; however, an increased pumping rate for an extended duration, as is planned for the Stress Test, could potentially result in a greater shift to the existing regional groundwater gradient. Applicable surface water and groundwater quality criteria are shown below in Table D-**1**. Table D-2 through Table D-4, mentioned in other sections, list various threshold and baseline values and Table D-5 (on page 10) lists the sampling logic.

Table D-1. Applicable Water Quality Standards for PCP and Related Contaminants

Source: DEQ, 2019.

Analyte	Human Health Standards (µg/L)		Aquatic Life (Chronic) Standard (µg/L)
	Surface Water	*Groundwater*	
Pentachlorophenol (PCP)	0.3	1	4 @ pH of 6.5
Polychlorinated biphenyls (PCB)	6 E-04	0.5	0.014
2,3,7,8-TCDD (Dioxin[1])	5 E-08	2 E-06	-

[1]: 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). For dioxin congeners (congeners of polychlorinated dibenzo-p-dioxins [CDDs] / polychlorinated dibenzofurans [CDFs]), equivalent concentration of 2,3,7,8-TCDD based on the toxicity equivalency factors (TEF) will apply. See Montana Circular DEQ-7 (DEQ, 2019).

µg/L: microgram per Liter.

2 Objectives

To fulfill the purpose stated above and ensure that the MPTP, NWE, or BRW sites are not adversely affected by the Stress Test, which could cause migration of and PCP, PCB, and variants of dioxin (congeners), the goals of PCP and related compounds monitoring are listed below followed by the main objectives.

1. Define an early detection network between BRW, NWE, and MPTP Sites.
2. Use the early detection network to monitor and limit the following:
    a. Adverse drawdown of the water table from the Stress Test.
    b. Migration of the regulated analytes (Table D-**1**).
    c. Discharge of PCP to surface water from BTL at concentrations above the appropriate standard (Table D-**1**).
3. Use the network to advise decision making for the Stress Test.

2.1 Objective 1: Define an Early Detection Network

The early detection network will need to be located on the MPTP property or between BRW and MPTP property and will be defined based on results from baseline sampling. It is anticipated that four new piezometers will be installed in this area as part of the BRW Phase III Quality Assurance Project Plan (QAPP) work or a subsequent change request. Additionally, two piezometers are proposed on NWE property and will be installed, pending access approval, under the BTL Stress Test QAPP or a subsequent change request.

These piezometers will be situated to detect a change in the groundwater flow direction prior to pumping effects negatively impacting the MPTP Site and may detect an increase in analyte concentrations prior to migration into the BRW Site.

Additionally, it is recommended that the following locations at the eastern end of the MPTP Site and western end of the BRW Site be considered for inclusion in the early detection network:

- MW-I-96
- MW-O-01
- BRW19-PZ46
- BRW19-PZ01S
- BRW-PW-01A
- BRW-PW-01B
- BRW-PW-02

Depending on the initial results of the baseline sampling, if any of the above suggested locations are not suitable or cannot be accessed, it is recommended that one or both of the following locations be substituted, as necessary:

- GW-17
- GW-13

2.2 Objective 2a: Monitor Changes in Water Table Elevation/Direction of Groundwater Flow

The current direction of groundwater flow in the area between the MPTP Site and BRW Site is to the north-northwest. While the Stress Test pumping activities at the BRW Site wells are unlikely to cause a shift in the groundwater gradient that will direct groundwater flow towards the BRW Site, the early detection network will also track groundwater elevations using transducers and manual water level measurements. The groundwater level monitoring network will be installed as follows:

- Transducers will be deployed in the selected locations listed in Objective 1 at the beginning of baseline sampling and will be downloaded at appropriate intervals during the Stress Test to record a water level measurement every 15 minutes. Telemetry at remote/difficult-to-access locations may be considered.
- Manual confirmation water levels will be recorded approximately every week subsequent to the installation of the transducers.
- During the Stress Test pumping activities, manual water level measurements may be collected more frequently than once per week to mirror the sampling frequency outlined in Table D-5 on page 10.
- Transducer data from the baseline period will be downloaded prior to the beginning of the Stress Test and weekly during the Stress Test. Data may be downloaded more frequently during the Stress Test if manual measurements indicate a notable change in water level.

Transducers will be uninstalled approximately one week after the conclusion of the Stress Test. Final manual water level measurements will be collected at the time the transducers are uninstalled.

2.3 Objective 2b: Monitor Changes in Chemical Concentration

The following estimates and assumptions were made to identify an appropriate interval of sampling with respect to the rate of change with chemical concentration:

- The range of estimated aquifer hydraulic conductivity (K) in this area is 12 feet to 315 feet per day (Atlantic Richfield, 2020).
- The distance (*dl*) from GW-17 to BRW19-PZ46 is approximately 330 feet.
- The anticipated drop in water table (*dh*) resulting from pumping during the Stress Test between GW-17 and BRW19-PZ46 is 0.8 feet.
- The assumed effective porosity (n_e) of the aquifer is 0.3.

The formula for groundwater velocity (V) is shown in Equation 1:

Equation 1: $$V = K * \frac{dh}{dl} * n_e$$

This equation was used to estimate the approximate velocity of groundwater in this area. The estimate used the range of hydraulic conductivity (12 feet to 315 feet per day) to estimate that groundwater would travel between 0.08 feet and 2.1 feet per day. It should be noted that the travel rate for PCP, PCB, and dioxins is notably slower than groundwater, primarily due to contaminant retardation. Using the most conservative (i.e., most conductive) estimate for hydraulic conductivity, it is estimated that groundwater will flow from GW-17 to BRW19-PZ46 in approximately 1,435 days (Figure D-1). Though this estimate is much longer than the estimated length of pumping for the Stress Test (6 to 8 weeks), changes should be monitored and considered for future construction dewatering.

All the contaminants of concern are relatively immobile, However, of the three analytes assessed here (PCP, PCB, and dioxin congeners), PCP is likely the most mobile in groundwater and therefore the most conservative. This analyte will therefore be used as an early indicator for monitoring changes in chemical concentration. Sampling the early detection system locations will allow for detection of changes in PCP concentration to fulfill Objective 1, Objective 2a and 2b, and Objective 3.

Appropriate Sampling Interval: Based on the above assessment of travel time, it is unlikely that groundwater from the MPTP Site will reach the BRW Site through advective flow. However, in an abundance of caution, monitoring chemical changes during the Stress Test will also allow monitoring potential changes in regulated analytes within the early detection network and avoid discharges of PCP to surface water from BTL at concentrations above the appropriate standards. Given that conservative assumptions indicate groundwater may travel up to 15 feet in 1 week, it is recommended that sampling (field screening and/or analytical sampling) during the Stress Test be collected once per week, with increases in sampling interval if changes in groundwater chemistry are observed (Table D-5 on page 10). Sampling intervals may be modified as appropriate by the Field Team Leader and Contractor Project Manager (CPM), in consultation with the Quality Assurance Officer (QAO) and Atlantic Richfield Quality Assurance Manager (QAM).

2.4 Objective 3: Decision-Making Thresholds for the Stress Test

Sampling results from the monitoring efforts will be interpreted as per Table D-5 on page 10 to advise the pumping activities for the Stress Test and minimize the risk of contaminant migration.

2.4.1 Identify Appropriate Threshold Values for Early Detection Network

The stress test will need to identify thresholds for groundwater and surface water standards; PCP has a human health standard of 1 microgram per Liter (µg/L) and a chronic aquatic life standard of 0.3 µg/L (Table D-**1**).

Chemical Threshold for Groundwater Standards**:** The Stress Test will need two chemical thresholds for groundwater, one to inform sampling at the pumping test locations and one to inform sampling at the early detection system locations.

The first groundwater threshold is for pumping well locations. The appropriate threshold for these locations is the human health standard of 1 µg/L. To ensure that these concentrations will not reach this level, a safety factor of 2 will be applied and the threshold PCP concentration at these locations will be 0.5 µg/L.

A second groundwater threshold will be required for all early detection system locations, including the pumping wells and locations with detectable concentrations of PCP above 1 µg/L. This threshold will be a notable increasing trend in PCP concentrations. The Stress Test will need to be modified or terminated if the concentration of PCP at one of the early detection system locations notably increases as per the Mann-Kendall test for trends with 95% confidence (Table D-2 and Table D-5 on page 10), using a minimum of the previous 6 most recent samples from the location.

Chemical Threshold for Surface Water Standards**:** The Stress Test will need to be modified or terminated if concentrations from the pumping wells will cause PCP concentrations at the effluent of BTL to increase above appropriate surface water standards (Table D-**1**). The dilution of groundwater from any single pumping well into the BTL system will be approximately 10x (i.e., the pumping rate at each pumping well will be approximately 100 to 150 gallons per minute [gpm], and flow into BTL is anticipated to range between 1,200 gpm and 2,000 gpm during the Stress Test). For PCP concentrations in the BTL effluent to reach 0.3 µg/L, the PCP concentration from any given pumping well would need to reach between 8 µg/L and 20 µg/L. This concentration range is above the threshold defined for groundwater standards of 0.5 µg/L (Table D-2), therefore the groundwater standard will dictate an appropriate response (Table D-5 on page 10).

Using the groundwater PCP concentration threshold and sampling activities to support detection of this threshold are further detailed in Table D-5 on page 10. The threshold values are summarized in Table D-2 below.

Table D-2. Proposed Threshold Values for Pentachlorophenol (PCP) during Stress Test

Location	Threshold Concentration to Modify Stress Test Pumping[1]	Threshold Concentration to Shut Down Stress Test
Early Detection System Network	Increase in Mann-Kendall with 95% confidence	2x initial concentration and increase in Mann-Kendall with 95% confidence
Pumping Wells	Increase in Mann-Kendall with 95% confidence and 0.25 µg/L PCP	2x initial concentration and increase in Mann-Kendall with 95% confidence and 0.5 µg/L PCP

Note: See Table D-5 for additional details. Based on the chart, composite samples may be collected for sampling during pumping only if each individual location has demonstrated non-detect concentration levels with the PCP screening kit and laboratory sampling. If any composite sample returns a PCP concentration of greater than 0.1 microgram per Liter (µg/L), then the individual locations will be sampled within that composite. The thresholds identified on Table D-2 may be modified by the CPM in consultation with the QAO and Atlantic Richfield QAM.

Threshold Values for Groundwater Drawdown: Excessive drawdown of the water table at the MPTP Site will need to be avoided at locations where contaminants are present at detectable quantities (Table D-**1**). Dioxins tend to be extremely hydrophobic and adhere to small soil particles near the water table. A common method for the transport of dioxin in groundwater is when the water table drops, dioxin-impacted soil particles are drawn downwards. When the water table recovers, these dioxin-impacted soil particles may become entrained in groundwater flow. If any dioxin has accumulated at the top of the water table, the drawdown created by the Stress Test pumping may draw these soil particles downward. Once the water table recovers, these particles could become entrained in groundwater flow.

The typical seasonal fluctuation in the water table has been used to estimate an acceptable drawdown for locations where contaminants are present at detectable quantities. The standard deviation for seasonal fluctuation of groundwater at the BRW Site is approximately 0.37 feet (Atlantic Richfield 2020, Table 7). At the time of the Stress Test, it is anticipated that groundwater elevations at the BRW Site will be at or near their annual peak. Therefore, the proposed threshold for drawdown in the area between the MPTP and BRW Sites is the estimated drawdown plus 2 standard deviations (95% of typical seasonal decrease); for the locations at the MPTP Site, the threshold for drawdown is proposed to be the estimated drawdown plus 1 standard deviation (68% of typical seasonal decrease). For a selection of wells in the monitoring network, drawdown thresholds are listed below in Table D-3. Drawdown at each early detection system location was estimated using the preliminary results from the BRW Site pumping test at BRW19-PW01A and the AQTESOLV modeling software.

Table D-3. Proposed Threshold Values for Groundwater Elevation Changes during Stress Test

*Location pending approval to access this location.

Location	Estimated Drawdown at 45 Days of Pumping (feet)	Proposed Threshold for Modifying Stress Test Pumping (feet)[1]	Threshold Standard Deviation
MW-I-96	<0.04	0.41	1
MW-O-01	<0.04	0.41	1
BRW21-PZ51	0.08	0.82	2
BRW21-PZ52	0.16	0.9	2
GW-17*	<0.04	0.41	1
GW-13*	<0.04	0.41	1

[1]These thresholds will only apply in these locations if concentrations of PCP have been detected above the detection limit. Proposed locations and threshold values for modifying Stress Test pumping may be modified based on proposed piezometer locations, access approval, or baseline field conditions by the Field Team Leader in consultation with the CPM and QAO.

If monitoring locations within the NWE yard are installed, this metric may be modified to monitor flow direction. If this metric is used, the test will be stopped if there is a reversal in flow direction for an extended period of time (i.e., one week).

2.5 Early Detection Sampling

Sampling performed at the early detection network locations will include baseline sampling to establish trends, and continued sampling during the stress test pumping activities to aid in decision making.

2.5.1 Baseline Sampling

Prior to the start of the Stress Test, baseline conditions will be established by sampling the early detection system locations approximately once per week until the start of the Stress Test, or until 6-8 samples are collected at each location. Sample splits will be collected for PCP screening kit analysis and laboratory analysis.

The laboratory samples will be collected from each of the selected early detection system locations and tested for detectable concentrations of the analytes specified in Table 6 of the BTL Stress Test QAPP (to which this document is an appendix), and summarized in Table D-4 below. If analytical results during the baseline period indicate non-detection in all analytes at a location, samples submitted from that location the following week may be submitted for a reduced analyte list. No composite samples will be collected during baseline sampling. The final configuration of baseline sampling analysis, timing, and locations may be modified by the Field Team Leader in consultation with the CPM and QAO as necessary to adapt to changing conditions and results.

Table D-4. Proposed Baseline Sample Collection at Monitoring Locations

Location	Field Screening	Laboratory		
	PCP	PCP	PCB[1]	Dioxin Congeners[1]
MW-I-96	X	X		X
MW-O-01	X	X		X
GS-13*	X	X		X
GS-17*	X	X		X
BRW21-PZ51	X	X		X
BRW21-PZ52	X	X		X
BRW-PW-01A	X	X	X	X
BRW-PW-01B	X	X	X	X
BRW-PW-02	X	X	X	X
BRW19-PZ46	X	X	X	X
BRW19-PZ01S	X	X	X	X

[1]Laboratory analysis of polychlorinated biphenyl (PCB) and dioxin congeners may be omitted due to continued non-detection in some locations, as determined by the Field Team Leader, CPM, and QAO.
*Location pending approval to access this location.

2.5.2 Sampling During Pumping

The early detection network locations will be refined by the Field Team Leader and CPM, in consultation with the QAO, based on the results of the available baseline sampling data. Sampling may be conducted on a weekly basis with laboratory splits being collected from each early detection monitoring location. The field PCP screening analysis will be used as a near 'real-time' indicator (i.e., appropriate 1-day turnaround) of changing conditions, while the laboratory splits will provide confirmation of screening kit results. Weekly laboratory split sample locations may be adjusted by the Field Team Leader, CPM, and QAO as necessary, but laboratory samples will be submitted from each location at the start and end of pumping, at a minimum, to compare to baseline analytical trends.

Composite Sampling: If more than one early detection system location demonstrates non-detect concentrations during baseline sampling, the Field Team Leader may collect composite samples from those locations returning non-detect values for PCP screening kit analysis.

If the PCP screening kit detects PCP in any composite sample at a concentration of 0.1 µg/L or greater, a sample from each well within the composite sample will need to be analyzed to determine the source(s) of the positive detect. Results from the individual samples will follow the logic outlined in Table D-5 on page 10.

2.6 Data Evaluation and Decision Making

At the end of baseline sampling, each available analyte result with concentrations above the contract required quantitation limit (CRQL) will be evaluated with the Mann-Kendall test for trends. The PCP screening kit and laboratory data collected during pumping test that are above the CRQL will be added to the baseline sampling Mann-Kendall test for trends, as available, and evaluated as per Table D-5 on page 10.

Decision Making Thresholds: Incremental responses to the PCP concentration threshold and the PCP trend threshold are detailed in Table D-5 on page 10. The primary response to increasing PCP concentrations will be the reduction of pumping rates from the BRW Site pumping wells to eliminate any detected or notable increases in PCP concentrations. If the threshold PCP concentration of 0.5 µg/L is measured at any BRW Site pumping well location, and/or notable increases in PCP concentration at any pumping well or early detection system location cannot be controlled through decreases in pumping rate, pumping activities at the BRW Site for the Stress Test will cease and the pumping configuration will be reevaluated.

Stress Test PCP, PCB, Dioxin, and Water Level Logic

Objective: Lay out a logical sequence for detecting PCP concentrations and trends in the production water from BRW pumping wells during the stress testDuring the Phase II pumping tests, no hydrocarbon species were detected above discharge criteria thresholds. Hydrocarbon sampling will continue to be performed during extended pumping for the stress test to ensure detectable hydrocarbon concentrations do not enter the BTL system. Increasing concentrations of total petroleum hydrocarbons in production water may correlate to increasing concentrations of criteria analytes in BTL effluent (e.g., benzene). Analytical sampling to confirm field-detected concentrations will be collected from the mixed production water.

Table D-5: Early Detection Sampling Logic: PCP, PCB, Dioxin, and Water Level:

Location	Stress Test Stage	Frequency	Analytes/ Measurement	Result	Then…	Logic
All	**Baseline**	**Weekly**	**PCP Screening Kit, Laboratory PCP, PCB, Dioxin Congeners**	Non-detect/Detect < 0.1 µg/L Detect >= 0.1 µg/L Detect > 0.5 µg/L	Note in logbook	Baseline PCP concentrations will be used to determine trends during pumping. Some locations may not be sampled for PCB and dioxin congeners due to continued non-detection, as determined by the Field Team Leader CPM, and QAO.
			Water Levels	Establish Baseline	Note in logbook.	Baseline water level elevations will be used to determine water level trends prior to pumping.
Pumping Wells	**Pumping**	**Weekly**	**PCP Screening Kit Sample**	Non-detect/Decrease in Mann-Kendall with 95% Confidence	Note in logbook and continue pumping.	If no PCPs are detected in the field kit, the risk of PCP contamination reaching BTL is low, and field testing will continue once per week.
				Increase in Mann-Kendall with 95% Confidence	•Note in logbook. •Increase PCP field screening frequency to twice per week. •If additional subsequent sample shows continued increase (as per Mann-Kendall), collect laboratory confirmation sample. •Notify Field Team Leader, CPM, QAO, and GW SME. **After one week** •If concentrations decrease below detection limit, continue pumping and reduce field testing to once per week. •If concentrations are not increasing (as per Mann-Kendall), reduce PCP screening kit sampling to once per week and collect laboratory confirmation sample. •If concentrations show continued increase (as per Mann-Kendall) and 2x average baseline concentration, follow procedure below.	Increasing concentration (as per Mann-Kendall) warrants modification of the stress test pumping. Field team leader will consult with the CPM, QAO, and groundwater SME to modify pumping rates at BRW19-PW01A and/or other BRW pumping locations. If concentrations decrease below detection, testing may be reduced to once per week.
				Increase in Mann-Kendall with 95% Confidence **and** 2x Average Baseline Concentration **or** Detected Concentration >= 0.25 µg/L	•Note in logbook and continue pumping; •Continue to field sample twice per week. **After one week** •If concentrations are not increasing (as per Mann-Kendall), reduce to once per week. • If concentrations decrease below detection, continue pumping and reduce field testing to once per week. •If concentrations increase to >= 0.25 µg/L, Notify Field Team Leader, CPM, QAO, and GW SME. **•If concentrations increase to >= 0.5 µg/L, Notify Field Team Leader, CPM, QAO, and GW SME.**	Increasing concentration (as per Mann-Kendall) at a magnitude of 2x average baseline concentration may indicate migration of PCP into the BRW area. Concentration >= 0.25 µg/L warrants possible modification of pumping to not exceed chemical threshold for groundwater or surface water standards. **Concentration >= 0.5 µg/L warrants possible cessation of pumping to not exceed chemical threshold for groundwater or surface water standards.** Analytical water quality samples will be collected and rush analyzed to confirm field results, and the CPM, QAO, and groundwater SME may make the decision to cease pumping until a corrective action is in place at any time after PCP concentrations are detected.
Early Detection System	**Pumping**	**Weekly**	**PCP Screening Kit Sample**	Non-detect/Decrease in Mann-Kendall with 95% Confidence	Note in logbook and continue pumping.	If no PCPs are detected in the field kit, the risk of PCP contamination reaching BTL is low, and field testing will continue once per week.
				Increase in Mann-Kendall with 95% Confidence	•Note in logbook. •Increase PCP field screening frequency to twice per week. •If additional subsequent sample shows continued increase (as per Mann-Kendall), collect laboratory confirmation sample. •Notify Field Team Leader, CPM, QAO, and GW SME. **After one week** •If concentrations decrease below detection limit, continue pumping and reduce field testing to once per week. •If concentrations are not increasing (as per Mann-Kendall), reduce PCP screening kit sampling to once per week and collect laboratory confirmation sample. •If concentrations show continued increase (as per Mann-Kendall) and 2x average baseline concentration, follow procedure below.	Increasing concentration (as per Mann-Kendall) warrants modification of the stress test pumping. Field team leader will consult with the CPM, QAO, and groundwater SME to modify pumping rates at BRW19-PW01A and/or other BRW pumping locations. If concentrations decrease below detection, testing may be reduced to once per week.
				Increase in Mann-Kendall with 95% Confidence and 2x Average Baseline Concentration	•Note in logbook and continue pumping; •Continue to field sample twice per week. **After one week** •If concentrations are not increasing (as per Mann-Kendall), reduce to once per week. • If concentrations decrease below detection, continue pumping and reduce field testing to once per week.	Increasing concentration (as per Mann-Kendall) at a magnitude of 2x average baseline concentration may indicate migration of PCP into the BRW area. Analytical water quality samples will be collected and rush analyzed to confirm field results, and the CPM, QAO, and groundwater SME may make the decision to cease pumping until a corrective action is in place at any time after PCP concentrations are detected.
Early Detection System	**Pumping**	**Weekly**	**Groundwater Elevation and Flow Direction**	Net drawdown > proposed threshold for modifying stress test pumping (see below)	•Note in logbook and continue pumping; increase manual water level monitoring to once per day. •Pumping rates will be adjusted, starting in order with BRW19-PW01A, -PW02, and PW01B. **After one week** •if water levels are not decreasing, reduce to once per week. •If water levels are still decreasing, adjust pumping rates to stabilize.	An increase in drawdown warrants more frequent manual water level measurements to determine if the drawdown is going to continue. Field team leader will consult with the CPM, QAO, and groundwater SME to modify pumping rates at BRW19-PW01A and/or other BRW pumping locations. If water levels indicate drawdown is no longer increasing, measurements may be reduced to once per week. After one week, pumping rates may be increased and monitored accordingly.
				Groundwater flow direction reversal in the MPTP area.	•Note in logbook and modify pumping; increase manual water level monitoring to once per day. •Pumping rates will be adjusted, starting in order with BRW19-PW01A, -PW02, and PW01B. **After one week** •if groundwater flow direction has returned to normal, continue pumping and reduce monitoring to once per week. •If groundwater flow direction is still reversed, stop the Stress Test.	An increase in drawdown warrants more frequent manual water level measurements to determine if the drawdown is going to continue. Field team leader will consult with the CPM, QAO, and groundwater SME to modify pumping rates at BRW19-PW01A and/or other BRW pumping locations. If water levels indicate drawdown is no longer increasing, measurements may be reduced to once per week. After one week, pumping rates may be increased and monitored accordingly.

Table D-5 Cont.: Early Detection Sampling Logic: PCP, PCB, Dioxin, and Water Levels

Laboratory Samples

Type	Preservation	Purpose		Frequency
Laboratory sample	Unfiltered, see table.	Confirm field kit accuracy		1 per 20 field test kit samples
Field Duplicate		Verify sampling procedures		1 per 20 samples
Equipment blank		Verify equipment decontamination procedures		1 per 20 samples, as needed.
Field Blank		Verify DI water concentration		1 per 20 samples, as needed.

Company	Sample Group	Analyte	Analytical Method	CRQL	Holding Time	Container Size	Preservation[1]	Locations
Eurofins TestAmerica or equivalent	8	Polychlorinated biphenyls (PCB)	EPA 8082A	0.45 µg/L	1 year	2, 250 mL amber glass	Raw, cool ≤6°C	*Confirmation samples following logic in Appendix D, or as determined by Field Team Leader and CPM.*
		Pentachlorophenol (PCP)	EPA 8270D SIM	1 µg/L	7 days	2, 250 mL amber glass		
		2,3,4,6 Tetrachlorophenol	EPA 8270E	5 µg/L	7 days	2-1L amber glass		
		2,3,5,6-Tetrachlorophenol		0.6 µg/L				
		2,4,6-Trichlorophenol		0.6 µg/L				
		2,4-Dichlorophenol		1 µg/L				
		2-Chlorophenol		1 µg/L				
		2,3,7,8-TCDD	EPA 1613B	10.0 µg/L	1 year			
		2,3,7,8-TCDF		10.0 µg/L				
		1,2,3,7,8-PeCDD		50.0 µg/L				
		1,2,3,7,8-PeCDF		50.0 µg/L				
		2,3,4,7,8-PeCDF		50.0 µg/L				
		1,2,3,4,7,8-HxCDD		50.0 µg/L				
		1,2,3,6,7,8-HxCDD		50.0 µg/L				
		1,2,3,7,8,9-HxCDD		50.0 µg/L				
		1,2,3,4,7,8-HxCDF		50.0 µg/L				
		1,2,3,6,7,8-HxCDF		50.0 µg/L				
		1,2,3,7,8,9-HxCDF		50.0 µg/L				
		2,3,4,6,7,8-HxCDF		50.0 µg/L				
		1,2,3,4,6,7,8-HpCDD		50.0 µg/L				
		1,2,3,4,6,7,8-HpCDF		50.0 µg/L				
		1,2,3,4,7,8,9-HpCDF		50.0 µg/L				
		OCDD		100 µg/L				
		OCDF		100 µg/L				

Proposed Drawdown Threshold for Modifying Stress Test Pumping

Location	Proposed Drawdown Threshold for Modifying Stress Test Pumping (feet)
MW-I-96	0.41
MW-O-01	0.41
BRW21-PZ51	0.82
BRW21-PZ52	0.9

3 DISCUSSION

The establishment of an appropriate early detection network between the BRW and MPTP Sites will ensure continued protection of the remedy in place at the MPTP Site and ensure that planned activities at the BRW Site will not cause any adverse change in conditions. Monitoring prior to and during the stress test at the early detection network locations will provide data to aid in decision making and enable the determination of threshold physical and chemical changes as a result of pumping. Future design related to remedial action construction at BTL may reference this dataset to continue protection of resources at both locations.

4 REFERENCES

Atlantic Richfield, 2021. Final Butte Reduction Works (BRW) Smelter Area Mine Waste Remediation and Contaminated Groundwater Hydraulic Control Site Phase II Quality Assurance Project Plan (QAPP). Atlantic Richfield Company, Revision 2, February 2021.

Atlantic Richfield, 2020. Draft Final Butte Reduction Works (BRW) Smelter Area Mine Waste Remediation and Contaminated Groundwater Hydraulic Control Site Phase II Pre-Design Investigation Evaluation Report. Atlantic Richfield Company, 2020.

DEQ, 2019. Circular DEQ-7 Montana Numeric Water Quality Standards. Montana Department of Environmental Quality, Water Quality Planning Bureau. Helena, MT. June 2019.

FIGURES

Figure D-1. Early Detection Monitoring Network

Legend

- Proposed Network Wells
- Network Wells
- Pumping Wells
- Conceptual Drawdown Flow Direction
- Conceptual Drawdown Contours
- Groundwater Flow Direction
- Groundwater Contours

N

DISPLAYED AS:
PROJECTION/ZONE: MSP
DATUM: NAD 83
UNITS: INT'L FEET
SOURCE: PIONEER/CADEARTH 2014

0 100 200 400
Feet

FIGURE D-1

PIONEER TECHNICAL SERVICES, INC.

MPTP PCP PLUME EARLY DETECTION NETWORK WELLS

DATE: 5/4/2021

Path: Z:\Shared\Active Projects\ARCO\BPSOU\GWRO\GIS\BTL_StressTest\StrsTst_BTL_006_21.mxd

Appendix E
Operations and Equipment Product Specification

PolyPipe® for MUNICIPAL & INDUSTRIAL

PolyPlus™ PE3408/PE4710

High Performance Pipe for Municipal & Industrial Applications

FEATURES:

- Suitable applications include Reclaim Water, Intake Water, Raw Water,Wastewater, Mining, Dredging, Landfill, Pulp & Paper and Power Generation
- Heat-fused, fully restrained, leak proof joints
- Maintains optimum flow rates due to resistance to corrosion & biological growth
- Fatigue resistant
- NSF-61 & NSF-14 certified
- Meets ASTM D3350 cell classification PE445574C
- Material grades PE3408/PE4710/PE100 per PPI TR-4
- ASTM D3035 & ASTM F714

SAMPLE PRINTLINE:	24'' IPS-SDR 11-DURALINE-POLYPIPE®POLYPLUS-PE3408/PE4710-CEE-ASTM F714-(Resin Code)(Color Code)-6GB -(ddmmyy)
APPLICATION:	Reclaim Water, Intake Water, Raw Water,Wastewater, Mining, Dredging, Landfill, Pulp & Paper, Power Generation and others
SIZE RANGE:	½" – 65" (IPS, DIPS)
COLOR/STRIPE:	Solid black, or with Stripes: white, red, yellow, gray, orange, blue, purple, green, pink, brown

PolyPipe is manufactured with high performance resins engineered with outstanding resistance to Slow Crack Growth (SCG) and Rapid Crack Propagation (RCP). The fatigue resistance of these resins improves design life in water systems where cyclic pressure surges exist.

Dura-Line is ISO 9001 certified and PolyPipe is qualified using exacting laboratory procedures and test methods, and a consistent uncompromised quest for design and manufacturing excellence.

PolyPipe® for POLYPLUS™

PolyPlus PE3408/PE4710

TYPICAL PHYSICAL PROPERTIES

PROPERTY	ASTM TEST METHOD	*NOMINAL VALUES	
		SI Units	English Units
Density, Natural	D1505	0.949 gm/cc	–
Density, Black	D1505	0.960 gm/cc	–
Melt Index (190°C/2.16 kg)	D1238	0.08 gm/10 min.	–
Flow Rate (190°C/21.6 kg)	D1238	7.5 gm/10 min.	–
Tensile Strength @ Yield	D638	24.8 MPa	3,500 psi
Ultimate Elongation	D638	>800%	>800%
Flexural Modulus	D790	1,034 MPa	150,000 psi
2% Secant			
Environmental Stress Crack Resistance (ESCR)			
F_0, Condition C	D1693	--	--
PENT	F1473	>500 hrs.	>500 hrs.
Brittleness Temperature	D746	<-117°C	<-180°F
Hardness, Shore D	D2240	64	64
Vicat Softening Temperature	D1525	124°C	255°F
Izod Impact Strength (Notched)	D256	0.42 KJ/m	8 ft – lb_f/in
Volume Resistivity	D991	$>10^{15}$ ohm-cm	--
Thermal Expansion Coefficient		$2x10^{-4}$ cm/cm/°C	$1.0x10^{-4}$ in/in/°F
CELL CLASSIFICATION:	D3350	445574C	PE47
		445576C	PE100
PPI HYDROSTATIC DESIGN BASIS (HDB)	D2837	11.0 MPa @ 23°C	1,600 psi @ 73.4°F
(As listed in PPI TR-4)		6.9 MPa @ 140°C	1,000 psi @ 140°F
PPI HYDROSTATIC DESIGN STRESS (HDS)		6.9 MPa @ 23°C	1,000 psi @ 73.4°F
(As established by the Hydrostatic Stress Board (HSB) of the Plastics Pipe Institute (PPI))			

*Nominal values are intended to be guides only, and not as specification limit.
*Some of the data listed above was determined from compression molded test specimens; therefore, may deviate from pipe specimens.

PolyPipe®

PE3408/PE4710/PE100 Pipe
Pipe Data and Pressure Ratings - IPS

ISO 9001 REGISTERED

Pressure Rating		DR7 335 psi		DR9 255 psi		DR11 200 psi		DR13.5 160 psi		DR17 125 psi		DR21 100 psi		DR26 80 psi		DR32.5 65 psi	
Nominal Pipe Size	OD (inches)	Min. Wall (inches)	Weight (lbs/ft)	Min. Wall (inches)	Weight (lbs/ft)	Min. Wall (inches)	Weight (lbs/ft)	Min. Wall (inches)	Weight (lbs/ft)	Min. Wall (inches)	Weight (lbs/ft)	Min. Wall (inches)	Weight (lbs/ft)	Min. Wall (inches)	Weight (lbs/ft)	Min. Wall (inches)	Weight (lbs/ft)
½″	0.840	0.120	0.119	0.093	0.096	0.076	0.080	–	–	–	–	–	–	–	–	–	–
¾″	1.050	0.150	0.185	0.117	0.150	0.095	0.126	–	–	–	–	–	–	–	–	–	–
1″	1.315	0.188	0.291	0.146	0.235	0.120	0.197	–	–	–	–	–	–	–	–	–	–
1 ¼″	1.660	0.237	0.463	0.184	0.374	0.151	0.314	0.123	0.261	–	–	–	–	–	–	–	–
1 ½″	1.900	0.271	0.607	0.211	0.490	0.173	0.411	0.141	0.342	–	–	–	–	–	–	–	–
2″	2.375	0.339	0.948	0.264	0.766	0.216	0.642	0.176	0.534	0.140	0.431	–	–	–	–	–	–
3″	3.500	0.500	2.058	0.389	1.664	0.318	1.395	0.259	1.159	0.206	0.936	0.167	0.768	0.135	0.626	–	–
4″	4.500	0.643	3.402	0.500	2.751	0.409	2.306	0.333	1.916	0.265	1.548	0.214	1.269	0.173	1.035	0.138	0.835
5″	5.375	0.768	4.854	0.597	3.925	0.489	3.289	0.398	2.733	0.316	2.208	0.256	1.810	0.207	1.477	0.165	1.192
5″	5.563	0.795	5.199	0.618	4.204	0.506	3.523	0.412	2.928	0.327	2.366	0.265	1.939	0.214	1.582	0.171	1.277
6″	6.625	0.946	7.374	0.736	5.963	0.602	4.997	0.491	4.152	0.390	3.355	0.315	2.750	0.255	2.244	0.204	1.811
7″	7.125	1.018	8.529	0.792	6.897	0.648	5.780	0.528	4.802	0.419	3.881	0.339	3.181	0.274	2.596	0.219	2.094
8″	8.625	1.232	12.498	0.958	10.106	0.784	8.470	0.639	7.037	0.507	5.687	0.411	4.662	0.332	3.804	0.265	3.069
10″	10.75	1.536	19.416	1.194	15.700	0.977	13.157	0.796	10.932	0.632	8.834	0.512	7.242	0.413	5.909	0.331	4.767
12″	12.75	1.821	27.312	1.417	22.085	1.159	18.508	0.944	15.379	0.750	12.427	0.607	10.187	0.490	8.312	0.392	6.703
14″	14.00	2.000	32.930	1.556	26.628	1.273	22.315	1.037	18.542	0.824	14.983	0.667	12.282	0.538	10.022	0.431	8.086
16″	16.00	2.286	43.010	1.778	34.779	1.455	29.146	1.185	24.218	0.941	19.569	0.762	16.042	0.615	13.090	0.492	10.561
18″	18.00	2.571	54.435	2.000	44.017	1.636	36.888	1.333	30.651	1.059	24.767	0.857	20.304	0.692	16.567	0.554	13.366
20″	20.00	2.857	67.203	2.222	54.342	1.818	45.541	1.481	37.840	1.176	30.577	0.952	25.066	0.769	20.453	0.615	16.501
22″	22.00	–	–	2.444	65.754	2.000	55.105	1.630	45.787	1.294	36.998	1.048	30.330	0.846	24.748	0.677	19.967
24″	24.00	–	–	2.667	78.253	2.182	65.579	1.778	54.490	1.412	44.031	1.143	36.095	0.923	29.452	0.738	23.762
28″	28.00	–	–	3.111	106.51	2.545	89.260	2.074	74.167	1.647	59.931	1.333	49.130	1.077	40.087	0.862	32.342
30″	30.00	–	–	3.333	121.63	2.727	102.467	2.222	85.141	1.765	68.798	1.429	56.399	1.154	46.019	0.923	37.128
32″	32.00	–	–	3.556	139.12	2.909	116.59	2.370	96.871	1.882	78.277	1.524	64.169	1.231	52.359	0.985	42.243
36″	36.00	–	–	4.000	176.07	3.273	146.78	2.667	121.96	2.118	99.069	1.714	81.214	1.385	66.267	1.108	53.464
42″	42.00	–	–	–	–	–	–	3.111	166.88	2.471	134.844	2.000	110.542	1.615	89.73	1.292	72.771
48″	48.00	–	–	–	–	–	–	–	–	2.824	176.122	2.286	144.381	1.846	117.808	1.477	95.047
54″	54.00	–	–	–	–	–	–	–	–	3.176	222.91	2.571	182.732	2.077	149.100	1.662	120.294
63″	63.00	–	–	–	–	–	–	–	–	3.706	303.398	3.000	248.72	2.423	202.94	1.938	163.73
65″	65.00	–	–	–	–	–	–	–	–	3.824	322.967	3.095	264.76	2.500	216.03	2.000	174.29

dura·line

*See notes on Page 4 for product and pressure rating information

PolyPipe®

PE3408/PE4710/PE100 Pipe
Pipe Data and Pressure Ratings - DIPS

ISO 9001 REGISTERED

Pressure Rating		DR7 335 psi		DR9 255 psi		DR11 200 psi		DR13.5 160 psi		DR17 125 psi		DR21 100 psi		DR26 80 psi		DR32.5 65 psi	
Nominal Pipe Size	OD (inches)	Min. Wall (inches)	Weight (lbs/ft)	Min. Wall (inches)	Weight (lbs/ft)	Min. Wall (inches)	Weight (lbs/ft)	Min. Wall (inches)	Weight (lbs/ft)	Min. Wall (inches)	Weight (lbs/ft)	Min. Wall (inches)	Weight (lbs/ft)	Min. Wall (inches)	Weight (lbs/ft)	Min. Wall (inches)	Weight (lbs/ft)
3″	3.96	0.566	2.635	0.440	2.130	0.360	1.785	0.293	1.483	0.233	1.199	0.189	0.983	0.152	0.802	0.122	0.647
4″	4.80	0.686	3.871	0.533	3.130	0.436	2.623	0.356	2.180	0.282	1.761	0.229	1.444	0.185	1.178	0.148	0.950
6″	6.90	0.986	7.999	0.767	6.468	0.627	5.421	0.511	4.504	0.406	3.639	0.329	2.984	0.265	2.434	0.212	1.964
8″	9.05	1.293	13.760	1.006	11.127	0.823	9.325	0.670	7.748	0.532	6.261	0.431	5.132	0.348	4.188	0.278	3.379
10″	11.10	1.586	20.700	1.233	16.739	1.009	14.028	0.822	11.656	0.653	9.418	0.529	7.721	0.427	6.300	0.342	5.083
12″	13.20	1.886	29.274	1.467	23.671	1.200	19.838	0.978	16.483	0.776	13.319	0.629	10.919	0.508	8.909	0.406	7.188
14″	15.30	2.186	39.329	1.700	31.802	1.391	26.652	1.133	22.145	0.900	17.894	0.729	14.669	0.588	11.969	0.471	9.657
16″	17.40	2.486	50.866	1.933	41.132	1.582	34.470	1.289	28.641	1.024	23.144	0.829	18.973	0.669	15.481	0.535	12.490
18″	19.50	2.786	63.885	2.167	51.659	1.773	43.292	1.444	35.972	1.147	29.067	0.929	23.829	0.750	19.443	0.600	15.687
20″	21.60	3.086	78.386	2.400	63.385	1.964	53.119	1.600	44.137	1.271	35.665	1.029	29.237	0.831	23.856	0.665	19.247
24″	25.80	–	–	2.867	90.431	2.345	75.785	1.911	62.970	1.518	50.883	1.229	41.713	0.992	34.035	0.794	27.460
30″	32.00	–	–	–	–	–	–	2.370	96.871	1.882	78.277	1.524	64.169	1.231	52.359	0.985	42.243
36″*	38.30	–	–	–	–	–	–	–	–	2.253	112.132	1.824	91.923	1.473	75.005	1.178	60.514
42″*	44.50	–	–	–	–	–	–	–	–	2.618	151.374	2.119	124.093	1.712	101.254	1.369	81.692
48″*	50.80	–	–	–	–	–	–	–	–	–	–	2.419	161.717	1.954	131.953	1.563	106.460
54″*	57.56	–	–	–	–	–	–	–	–	–	–	2.741	207.620	2.214	169.408	1.771	136.678
60″*	61.61	–	–	–	–	–	–	–	–	–	–	–	–	2.370	194.086	1.896	156.588

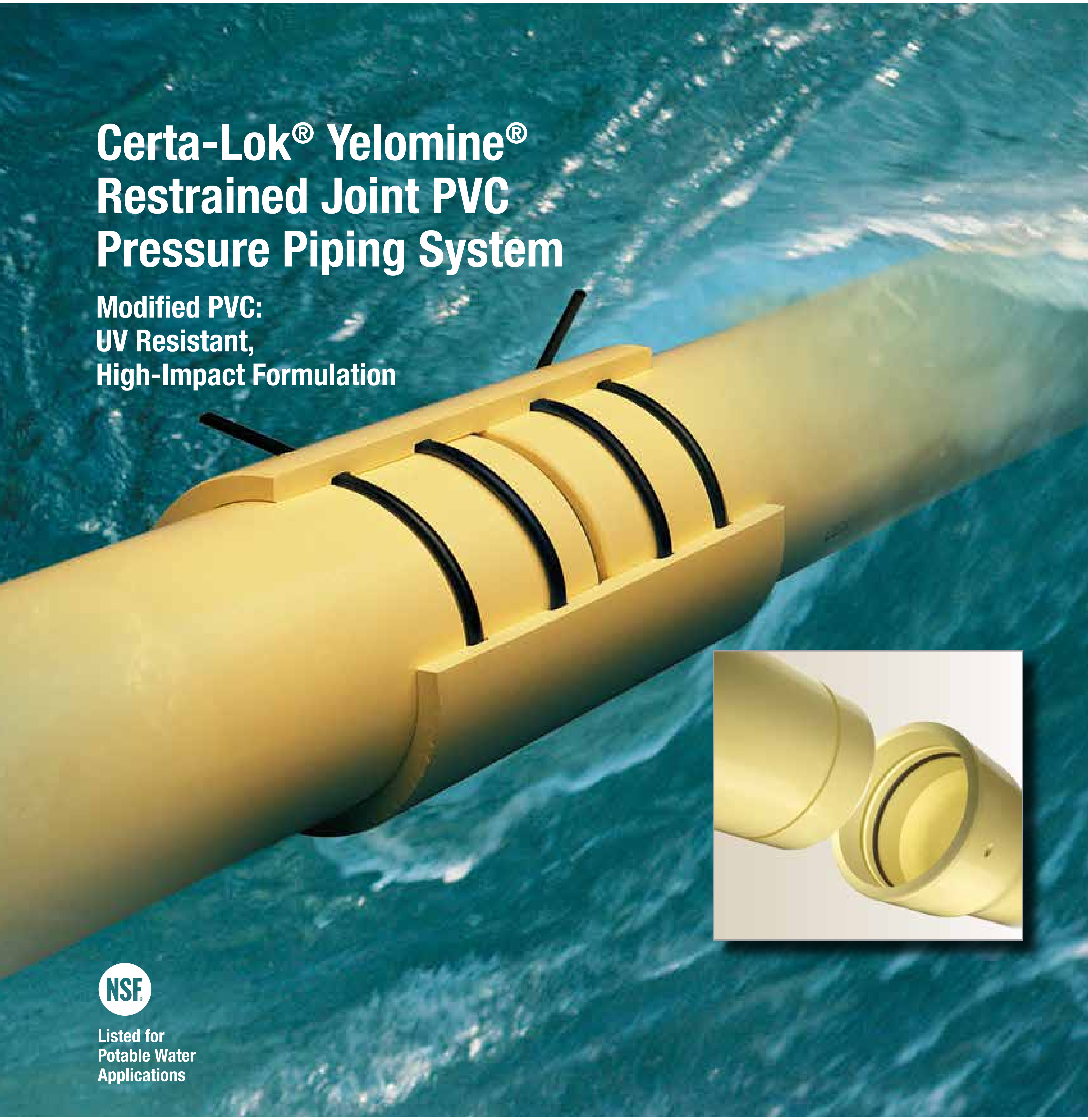
PolyPipe® PolyPlus™ PE4710 Pipe is manufactured in accordance with the following standards:

- For sizes ½″ IPS through 3″ IPS products are manufactured in accordance with ASTM D3035 & AWWA C901.
- For sizes 4″ IPS through 60″ DIPS products are manufactured in accordance with ASTM F714 & AWWA C906.
- Metric sizes also available.
- Coiled pipe available through 6″ OD and straight lengths available in 40′ and 50′ lengths. For custom lengths, contact a Customer Service Representative.

- Pressures are based on water at 23°C (73.4°F) and are determined by use of the Hydrostatic Design Stress (HDS) as established by the Hydrostatic Stress Board (HSB) of the Plastics Pipe Institute (PPI).
- The above weights for IPS and DIPS sizes are calculated in accordance with Plastics Pipe Institute (PPI) TR-7, using a value of 0.960 for density.
- Available with color-coded striping.
- Some sizes listed are special order. Call for availability on sizes.
- *May require additional lead time.

Certa-Lok® Yelomine® Restrained Joint PVC Pressure Piping System

Modified PVC: UV Resistant, High-Impact Formulation



NSF

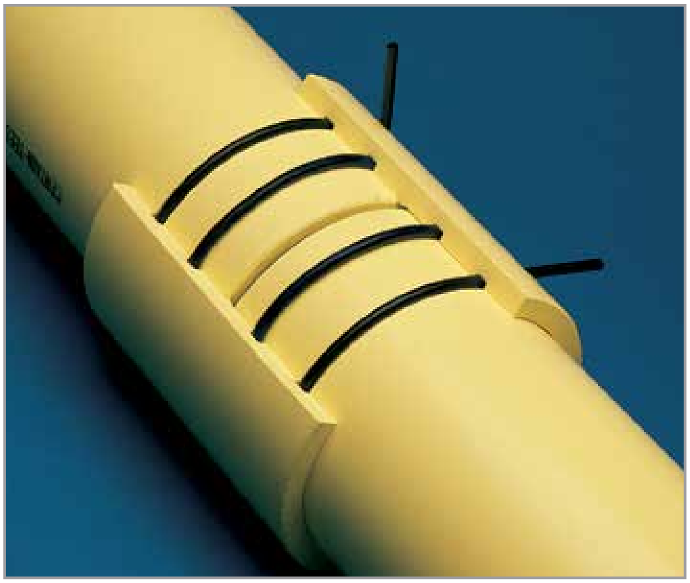
Listed for Potable Water Applications

NAPCO PIPE & FITTINGS

CERTA-LOK®, YELOMINE®

Restrained Joint PVC Pressure System

Certa-Lok Yelomine is designed and engineered to meet your tough or restrained joint piping requirements. The Certa-Lok Yelomine piping system can provide a unique solution to many of your specialty and standard piping system needs, whether for temporary or permanent installations.



Certa-Lok Yelomine is performance proven for a broad range of piping applications.

The unique Certa-Lok Yelomine joining system and superior physical properties limit possible applications to only the imagination and ingenuity.

Certa-Lok Yelomine pipe and fittings are available in 2" through 16" diameters, in pressure classes of 125 to 315 psi. Low pressure (100 psi) pipe is also available; call for details. Certa-Lok Yelomine is manufactured with IPS outside diameters and is available in 20' laying lengths.

Certa-Lok Yelomine is manufactured from a specially formulated PVC compound that contains impact modifiers and UV (ultraviolet) inhibitors. These modifiers and inhibitors provide higher impact strength over an extended period of time and allow Certa-Lok Yelomine to be used in above-ground, exposed applications as well as in underground or buried applications.

Only high-strength PVC compound having a minimum cell classification of 12454, as defined in ASTM D1784, is used in the production of Yelomine pipe and couplings.

The inherent properties of PVC provide a product that will not rust or corrode, and is extremely resistant to harsh environments, acids and most chemicals.

Certa-Lok self-restraining joint technology

Certa-Lok Yelomine pipe, couplings and fittings provide a restrained joint by utilizing precision-machined grooves on the pipe and in the coupling which, when aligned, allow a spline to be inserted, resulting in a fully circumferential restrained joint that locks the pipe and coupling together. A flexible elastomeric seal (O-ring) in the coupling provides a hydraulic pressure seal.

The Certa-Lok joint is fast, simple and reliable, and requires no solvent welding, butt fusion welding, bolting, wrenches or specialty equipment to assemble. Assembled joints are strong and typically require no thrust blocking.

Certa-Lok Yelomine joints can be easily disassembled, allowing for system changes, extension, movement or reuse of the entire system.

NAPCO offers a comprehensive line of Certa-Lok Yelomine fittings including: change of direction (elbows, sweeps, tees), adapters to other materials, joining systems (flange adapters, threaded adapters, metal-groove) and service outlets (tapped couplings).

Certa-Lok Yelomine allows for easy field fabrication. When making field cuts, it is best to use a PVC pipe cutter to ensure a square cut end. Square cuts are essential to ensure proper alignment. A conventional saw or power saw may be used if a pipe cutter is not available. NAPCO offers a power routing tool for field fabrication of the pipe groove required on Certa-Lok Yelomine. For cutting and grooving instructions, see “Certa-Lok Yelomine Specifications and Dimensions.”

Applications

- Above-Ground Pressure Lines
- Buried Pressure Lines
- Bridge Crossings
- River & Creek Crossings
- Supply Lines (Permanent)
- Supply Lines (Temporary)
- Trenchless
- Temporary Bypass
- Industrial Piping
- Process Piping
- Transmission Lines
- Lake and Pond Intake
- Tough Terrain
- Aeration Supply Lines
- Sewer Force Mains
- Boat Dock Water & Sewer Lines
- Gravity Sewer
- Unstable Soil Applications
- Bridge & Highway Drainage
- Temporary Potable Water & Fire Supply Lines for Recreation Areas
- Road Crossings
- Heap-Leach Mining
- Vacuum Lines
- Effluent and Reclaimed Water Lines
- Emergency Water Systems

CERTA-LOK® JOINT

Non-Permanent Use and Permanent Use

Certa-Lok Yelomine pipe and fittings have been successfully servicing the industry for many years. In order to enhance performance and better accommodate customer needs, we offer two types of Certa-Lok Yelomine: Permanent Use and Non-Permanent Use. Both couplings are similar in design; the main difference is the O-ring supplied. Non-Permanent O–rings have a slightly reduced cross-section for easy assembly and disassembly. Permanent Use O-rings have a slightly larger cross-section and are not designed for disassembly. Both types of rings are Teflon®-coated.

Non-Permanent Use Certa-Lok Joint

SIZES 2" THRU 16"
Non-Permanent Use Certa-Lok Joints are typically used in above-ground, exposed installations, such as temporary bypass or any installation that requires disassembly and reuse.

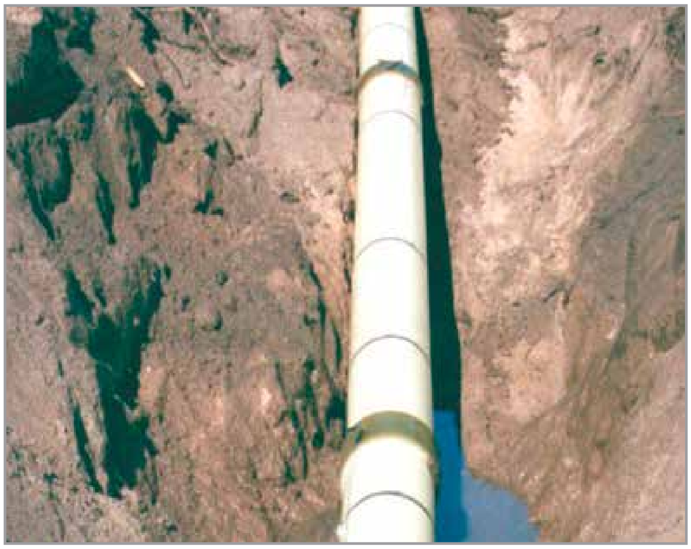
CAUTION: Non-Permanent Use Certa-Lok Joints should not be used in buried or submerged applications.

Permanent Use Certa-Lok Joint

SIZES 2" THRU 16"
Permanent Use Certa-Lok Joints utilize an O-ring with a slightly larger cross-section. The joint assembles easily with lubricant. Disassembly can be achieved, but can be extremely difficult depending on the diameter of the piping system.

Permanent Use Certa-Lok Joints are intended for use in all installations that do not require disassembly during the service life of the system. Applications include buried installations, bridge, river and road crossings, and all installations that would expose joints to long-term or excessive misalignment due to external loads.

If in doubt as to which system (Non-Permanent or Permanent Use) is best suited for your application, contact your NAPCO distributor or territory manager.



NOTE:
Some sizes are supplied with molded couplings, which have identical designs for permanent and non-permanent joints.

CERTA-LOK® YELOMINE®

Fundamental Features and Advantages

Impact Strength

Certa-Lok Yelomine greatly exceeds the impact strength of conventional PVC. Impact strength tests are regularly made on the product in accordance with ASTM standard test method D2444. Average impact values are up to five times greater than the impact resistance of conventional PVC pipe.

Impact Production Specifications

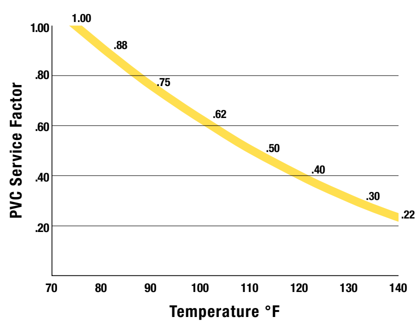
Nom. Size	SDR 26	SDR 21	SDR 17 SDR 13.5	Std. Pipe (All SDRs)
2"			170	30
3"			245	60
4"	210	255	320	90
6"	305	380	470	120
8"	400	495	610	160
10"	500	530		160
12"	500	530		160
14"	500	530		160
16"	500	530		160

NSF Approved

Yelomine is designed and manufactured in accordance with ASTM D2241.
2" through 16" PVC pipe and couplings up to Class 250 are listed in NSF Standard 14, “Plastic Piping System Components and Related Materials” for performance. All other products have a potable water listing in accordance with NSF 61.

PVC Temperature Service Factor

All pressure ratings for PVC pipe are determined in a water environment of 73.4°F (±3.6°F). As the temperature of the environment increases, PVC pipe becomes more ductile. This can be represented by graphs that show that the impact strength increases and the tensile strength decreases as the temperature rises. Because of this effect, the pressure rating of the pipe must be decreased to allow for safe operation of the line at elevated temperatures.



PVC Pipe Pressure Ratings for temperatures from 73.4°F to 140°F (for pressure rating at a temperature above 73.4°F, multiply the rating at 73.4°F by the corresponding service factor from the graph).

Non-Corrosive/ Chemical Resistant

Certa-Lok Yelomine is an excellent product for harsh environments. The inherent properties of PVC provide a product that is a non-conductor, which will not rust or corrode. Certa-Lok Yelomine is a product that does not require any cathodic protection, coating, wraps or other corrosion protection. PVC is extremely resistant to acids and most chemicals, and is unaffected by “hot” (aggressive) soils. Certa-Lok Yelomine has outstanding resistance to scale and scale buildup. And, if necessary, it can be cleaned by pigging the line.

Special splines and O-rings may be required in either extremely acidic applications or hydrocarbon environments.

High Flow Rate

Certa-Lok Yelomine offers a smooth, non-wettable interior surface that accounts for a Hazen-Williams flow coefficient of C=150.

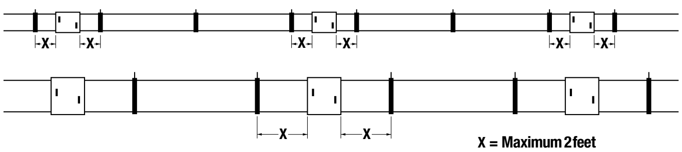
Light Weight

Two-inch Certa-Lok Yelomine weighs less than one pound per foot; 12" diameter (SDR26) weighs only 13 pounds per foot. This means most pipe sizes can be easily handled manually, even in 20' lengths, thus eliminating the need for heavy lifting equipment, and providing the ability to get into hard-to-reach areas like those found in tunnels.

SUPPORT SPACING FOR ABOVE-GROUND APPLICATIONS

No Thrust Blocking Required
Certa-Lok Yelomine does not typically require thrust blocking for support, due to its restrained joint design.

When adapting to other piping systems, such as metal-groove or non-restrained joints, use of thrust blocking is necessary. Also, connections to valves, pumps, pressure regulators and other appurtenances may require normal thrust blocking.



In some above-ground applications, Certa-Lok Yelomine is suspended on hangers, brackets or other supports. Proper bearing and spacing of supports is necessary to prevent excessive bending or sagging.

Supports must provide a smooth bearing surface conforming to the contour of the bottom half of the pipe. Bearing surfaces must be a minimum of 2" wide. Supports must permit longitudinal pipe movement for expansion and contraction, and must be mounted in such a way as to prevent lateral or vertical pipe movement. It is recommended that a support be secured to the pipe on both sides of a joint in order to minimize load on the joint, with the spacing between support and joint not to exceed 2 feet. The table can be used as a guide in determining hanger spacing.

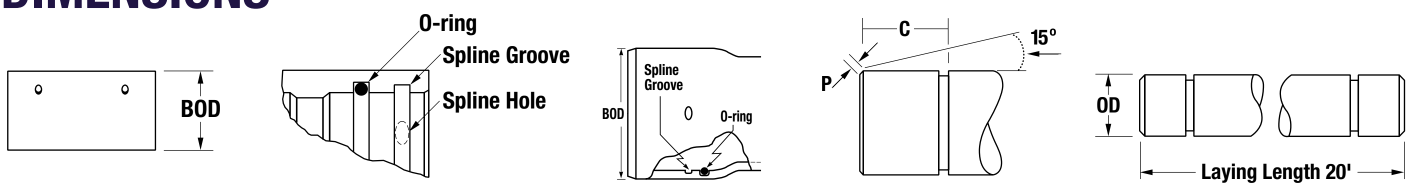
Support Spacing for Suspended Pipe	
Size	**Support Spacing**
2"- 4"	4' - 7'
6"	7' - 9'
8"-16"	9' - 17'

General guidelines only; consult the Uni-Bell Handbook of PVC Pipe Design and Construction for specific recommendations.

Yelomine Integral Bell (IB) Piping Products Dimensions - O-ring and Spline included										
Size psi	**Rating**	**SDR**	**O.D.**	**BOD**	**P**	**C**	**Min. Wall**	**Weight lbs./ft.**	**Non-Perm Part No.**	**Perm Part No.**
4"	200	21	64	5.11	1/4	3.00	.214	1.89	266225	266324
4"	250	17	24	5.27	1/4	3.00	.265	2.29	266218	266317
6"	200	21	26	7.50	1/4	3.00	.316	4.07	266249	266348
6"	250	17	24	7.74	1/4	3.00	.390	4.94	266232	266311
8"	200	21	20	9.75	21/32	3.16	.410	6.72	266379	266362

*Refer to illustration on the next page.

DIMENSIONS



Flexibility

Certa-Lok Yelomine can bend easily around many obstructions, typically reducing the number of fittings required. Pipe must not be bent to a lesser (tighter) radius than shown here.

Certa-Lok Yelomine Pipe with Couplings Dimensions - Certa-Lok Coupling and Spline included[2]									
Size (psi)	Rating	SDR	O.D.	BOD	P	C	Min. Wall	App. wt. lbs./ft.	Part No.[1,2]
2"	250	17	2.375	3.31	3/16	1.75	.140	0.69	216213
3"	250	17	3.500	4.435	3/16	2.50	.206	1.48	217210
4"	200	21	4.500	5.526	3/16	3.00	.214	2.11	226212
4"	250	17	4.500	5.47	3/16	3.00	.265	2.50	218217
6"	160	26	6.625	7.84	5/16	3.00	.255	3.58	235214
6"	200	21	6.625	7.84	5/16	3.00	.316	4.30	227219
6"	250	17	6.625	7.84	5/16	3.00	.390	5.18	219214
8"	160	26	8.625	10.19	21/32	3.16	.332	6.07	236211
8"	200	21	8.625	10.19	21/32	3.16	.410	7.26	228216
8"	250	17	8.625	10.95	21/32	3.16	.508	8.71	220210
10"	160	26	10.750	12.44	21/32	3.50	.413	9.73	214219
10"	200	21	10.750	12.44	21/32	3.50	.511	11.60	230219
12"	160	26	12.750	14.65	21/32	3.63	.490	13.63	215223
12"	200	21	12.750	14.65	21/32	3.63	.606	16.21	239229
14"	160	26	14.000	16.00	21/32	3.50	.538	14.70	247217
14"	160[3]	21	14.000	16.00	21/32	3.50	.666	18.03	247200
16"	90[3]	26	16.000	17.40	21/32	3.61	.615	20.37	248214[4]
16"	160	26	16.000	17.22	21/32	3.61	.615	20.22	248214[4]
16"	200	21	16.000	17.22	21/32	3.61	.762	24.85	248337

Certa-Lok Yelomine Pipe Installation Specifications						
Size	SDR	Note	Tightest Permissible Bend*		Resistance to Hydraulic Collapse Pressure (RHCP) psi	Max. Pull-in Force, Straight Pull (no Bending) lbs.
			Min. R. Curvature, ft.	Offset 20 ft. (in.)		
2"	17	2	40	59	224	1,900
3"	17	2	58	41	224	5,200
4"	21	1	75	32	115	8,700
4"	17	1	75	32	224	9,000
6"	21	1	110	22	115	10,900
6"	17	1	144	22	224	15,000
8"	21	1	144	17	115	20,600
8"	17	2	179	17	224	17,200
10"	21	2	213	13	115	27,200
12"	21	2	233	11	115	31,500
14"	26	2	233	10	59	29,000
14"	21	2	267	10	115	29,000
16"	26	2	267	9	59	27,000
16"	26	3	267	9	59	62,000
16"	21	3	267	9	115	62,000

HP = High Pressure

Note: All dimensions are in inches and are subject to normal manufacturing tolerances.

1 Specify Permanent or Non-Permanent.
2 Pipe may also be purchased without couplings, if desired. Use same part number, and specify "Pipe Only" on P.O.
3 PSI on this item is limited by the pressure rating of the coupling.
4 Specify desired pressure rating on P.O.

* Resistance to Hydraulic Collapse Pressure (RHCP) psi
Note: Excessive mud pressure can damage thinner wall products, which have lower collapse resistance ratings. Therefore, caution must be exercised if SDR26 products are used for directional drilling applications.

1 Integral Bell PVC products.
2 PVC coupling.
3 Composite coupling.

JOINT ASSEMBLY

Certa-Lok Yelomine Restrained Joint PVC Pipe

Clean
Clean interior of coupling and pipe spigot. Use a clean rag or paper towel to remove all foreign material. Make sure gaskets are clean and evenly seated in the gasket groove.

Lubrication
Lubrication is required for:

- All permanent use Certa-Lok Yelomine joints
- All non-permanent use Certa-Lok Yelomine joints 8" and above (lubrication is suggested, but may not be necessary for sizes 6" and below)

Do not lubricate splines before inserting into couplings. Use a spline insertion tool if necessary for pipe 8 inches and larger in diameter.

NAPCO supplies sufficient lubricant to join the pipe. Use only the approved lubricant supplied.

CAUTION: Lubricants not specifically formulated for this purpose may deteriorate the pipe and/or the gasket.

When using lubricant, apply only to the exposed gasket surface and to the tapered end of the pipe. Do not apply lubricant to the pipe or coupling spline grooves or spline. Lubricant in these areas can reduce joint strength.

For trenchless installations, follow guidelines for bend radius and pulling forces on page 7. Also, after pipe pull-in is complete, apply push force on pipe to relieve any stretch that may remain in pipe.

Assembly
After applying lubricant, align the pipe and coupling and push the pipe into the coupling. When the pipe end seats against the stop in the coupling, spline grooves are automatically aligned for spline insertion. Use a bar and block if needed; a "Comealong" or puller also can be used if sufficient care is taken to protect the pipe from chains.

The spline is then inserted through the spline insertion hole in the coupling and into the aligned grooves, until it has traveled a full 360° and is seated against itself (NAPCO offers a spline insertion tool that may be helpful, especially in larger pipe sizes).

The spline securely locks the coupling to the pipe. The gasket in the coupling is designed to provide a hydraulic seal. Note: If needed, the joint can be disassembled and re-used to allow for system changes, extension or removal for re-use.

Building Responsibly with PVC Pipe

- PVC resin starts with two simple building blocks: chlorine (57%) from common salt, a plentiful inexhaustible raw material, and ethylene (43%) from natural gas. Most of the natural gas utilized to manufacture ethylene is domestically produced, which reduces consumption of imported oil products.
- PVC pipe manufacturing is an extremely efficient process. The ability to immediately return scrap and off-specification materials (regrind) directly into the manufacturing process results in virtually no manufacturing waste.
- PVC pipes are completely recyclable and consume less energy to produce than alternative pipes.
- Smooth and corrosion-resistant PVC lowers flow losses and reduces energy costs for pumping water.
- Durability and long life: The number of recorded failures in PVC pipes is low compared to other materials (AWWA Research Foundation, 2005) — valuable water resources are conserved.
- Considering equipment utilization and reduced traffic disruption, trenchless construction methods using restrained joint PVC pipes result in significantly lower carbon outputs compared to conventional open-cut methods.
- PVC is often used to pump reclaimed, treated wastewater for applications such as irrigation of parks — conserves highly treated, expensive drinking water.

1.855.624.7473 I napcopipe.com

NAPCO
2801 Post Oak Blvd., Suite 600
Houston, TX 77056

CD100M Dri-Prime® Pump

WITH FINAL TIER 4 (FT4) ENGINE

The Godwin Dri-Prime CD100M pump offers flow rates to 920 USGPM and has the capability of handling solids up to 1.8" in diameter.

The CD100M is able to automatically prime to 28' of suction lift from dry. Automatic or manual starting/stopping available through integral mounted control panel or optional wireless-remote access.

Indefinite dry-running is no problem due to the unique Godwin liquid bath mechanical seal design. Solids handling, dry-running, and portability make the CD100M the perfect choice for dewatering and bypass applications.

Features and Benefits

- Simple maintenance normally limited to checking fluid levels and filters.
- Dri-Prime (continuously operated Venturi air ejector priming device) requiring no periodic adjustment. Optional compressor clutch available.
- Extensive application flexibility handling sewage, slurries, and liquids with solids up to 1.8" in diameter.
- Dry-running high pressure liquid bath mechanical seal with high abrasion resistant solid silicon carbide faces.
- Close-coupled centrifugal pump with Dri-Prime system coupled to a diesel engine or electric motor.
- All cast iron construction (stainless steel construction option available) with cast steel impeller.
- Also available in a critically silenced unit which reduces noise levels to less than 70 dBA at 30'.
- Standard engine Yanmar 3TNV88F (FT4).

Specifications

Suction connection	4" 125# ANSI B16.1
Delivery connection	4" 125# ANSI B16.1
Max capacity	920 USGPM †
Max solids handling	1.8"
Max impeller diameter	9.1"
Max operating temp	176°F*
Max pressure	45 psi
Max suction pressure	41 psi
Max casing pressure	83 psi
Max operating speed	2200 rpm

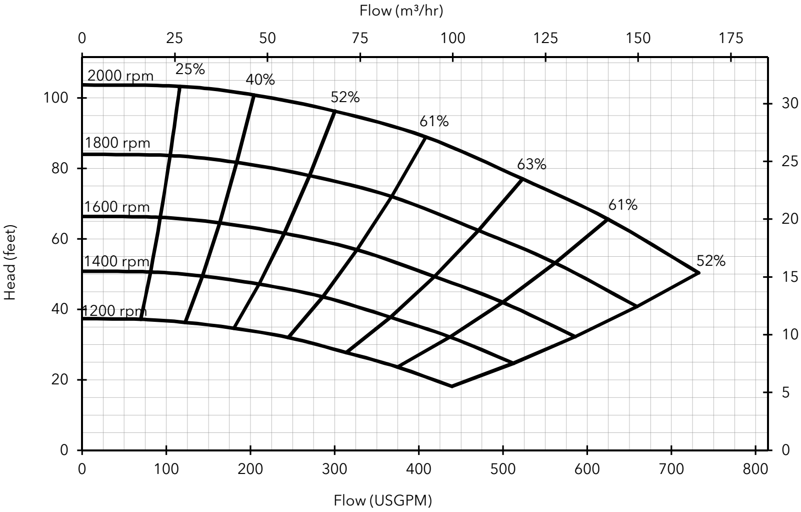
* Please contact our office for applications in excess of 176°F.

† Larger diameter pipes may be required for maximum flows.

Please contact the factory or office for further details. A typical picture of the pump is shown.
All information is approximate and for general guidance only.

godwin
a xylem brand

Performance Curve



Materials

Pump casing & suction cover	Cast iron BS EN 1561 - 1997
Wearplates	Cast iron BS EN 1561 - 1997
Pump Shaft	Carbon steel BS 970 - 1991 817M40T
Impeller	Cast Steel BS3100 A5 Hardness to 200 HB Brinell
Non-return valve body	Cast iron BS EN 1561 - 1997
Mechanical seal	Silicon carbide face; Viton elastomers; Stainless steel body

Engine option 1

Yanmar 3TNV88F (FT4), 23 HP @ 2000 rpm

Impeller diameter 9.1"

Pump speed 2000 rpm

Suction Lift Table

Total Suction Head (feet)	Total Delivery Head (feet)				
	12	34	45	59	70
	Output (USGPM)				
10	869	793	716	614	496
15	818	742	665	563	409
20	639	604	563	486	358
25	409	384	358	307	205

Fuel capacity: 30 US Gal

Max Fuel consumption @ 2000 rpm: 1.2 US Gal/hr

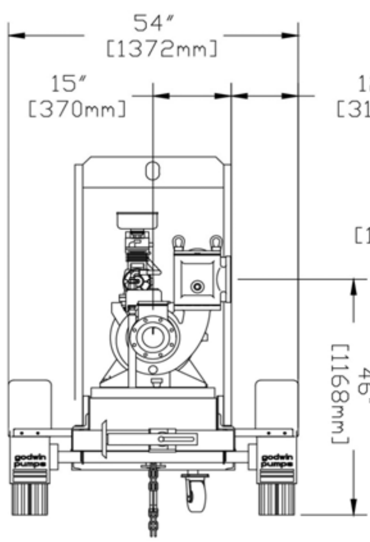
Max Fuel consumption @ 1800 rpm: 1.1 US Gal/hr

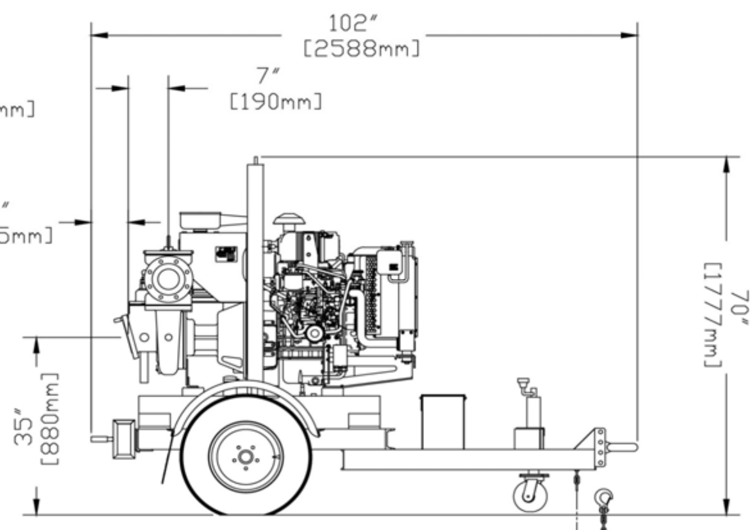
Weight (Dry): 1,800 lbs

Weight (Wet): 2,020 lbs

Dim.: (L) 102" x (W) 54" x (H) 70"

Performance data provided in tables is based on water tests at sea level and 20°C ambient. All information is approximate and for general guidance only. Please contact the factory or office for further details.





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Reference number : 200GPA0000900
Date of issue : May 11, 2017
Issue : A

www.godwinpumps.com

Taylor-Wharton

Liquid Cylinders

LIQUID CYLINDERS

Portable vacuum-insulated containers that provide convenient and economical means of transporting, storing and dispensing liquefied gases.

- Full Circle® Shock-Mount Ring*
- Polished Heavy Duty Outer Body
- Innovative Non-Binding Contents Gauge
- Reinforced Lateral Head Support
- Color-Coded Relief Valves for Different Pressure Settings
- Protective Nylon Shipping Sleeve**
- 5-Year Warranty on Vacuum

Taylor-Wharton

GL Series

GL SERIES - Gas and Liquid Withdrawal
Medium Pressure *XL-45, XL-50, XL-55, XL-65 and XL-70*

Liquid or Gaseous Nitrogen, Oxygen, Argon

These over-the-road transport cylinders feature automatic pressure-building and economizer circuits. Low-loss holding capabilities help conserve gas during low demand periods. These units are considered the workhorses of the industry.

	XL-45	XL-50	XL-55	XL-65	XL-70
Dimensions					
Diameter	20 in. (508 mm)	20 in. (508 mm)	20 in. (508 mm)	26 in. (660 mm)	26 in. (660 mm)
Height	61 3/8 in. (1559 mm)	64 5/8 in. (1641 mm)	69 7/16 in. (1764 mm)	59 1/2 in. (1511 mm)[4]	63 1/4 in. (1607 mm)
Weight					
Empty (Nominal)	255 lb. (116 kg)	270 lb. (122 kg)	270 lb. (122 kg)	N/A	N/A
5 caster base	N/A	N/A	N/A	375 lb. (170 kg)	395 lb. (179 kg)
4 caster base	N/A	N/A	N/A	445 lb. (202 kg)	465 lb. (211 kg)
Maximum Liquid Capacity	180 liters	193 liters	210 liters	250 liters	280 liters
Usable Liquid Capacity	169 liters	181 liters	200 liters	240 liters	265 liters
Normal Evaporation Rate[1] % Capacity per Day					
Oxygen	1.2%	1.1%	1.1%	0.9%	1.0%
Nitrogen	1.9%	1.8%	1.7%	1.4%	1.6%
Argon	1.2%	1.1%	1.1%	0.9%	1.0%
Carbon Dioxide	N/A	N/A	N/A	N/A	N/A
Nitrous Oxide	N/A	N/A	N/A	N/A	N/A
Gas Withdrawal Rate[2] @ NTP (STP)					
Oxygen	350 cfh (9.2 cu. m/h)	350 cfh (9.2 cu. m/h)	350 cfh (9.2 cu. m/h)	350 cfh (9.2 cu. m/h)	350 cfh (9.2 cu. m/h)
Nitrogen	350 cfh (9.2 cu. m/h)	350 cfh (9.2 cu. m/h)	350 cfh (9.2 cu. m/h)	350 cfh (9.2 cu. m/h)	350 cfh (9.2 cu. m/h)
Argon	350 cfh (9.2 cu. m/h)	350 cfh (9.2 cu. m/h)	350 cfh (9.2 cu. m/h)	350 cfh (9.2 cu. m/h)	350 cfh (9.2 cu. m/h)
Carbon Dioxide	N/A	N/A	N/A	N/A	N/A
Nitrous Oxide	N/A	N/A	N/A	N/A	N/A
Dual Pressure Building/ Economizer Regulator[3]					
Pressure Building	125 psig (8.6 bar/862 kPa)	125 psig (8.6 bar/862 kPa)	125 psig (8.6 bar/862 kPa)	125 psig (8.6 bar/862 kPa)	125 psig (8.6 bar/862 kPa)
Economizer Setting	145 psig (10 bar/1000 kPa)	145 psig (10 bar/1000 kPa)	145 psig (10 bar/1000 kPa)	145 psig (10 bar/1000 kPa)	145 psig (10 bar/1000 kPa)
Design Specification					
TC N/A	4LM	4LM	4LM	4LM	4LM
DOT	4L	4L	4L	4L	4L
Rated DOT Service	200 psig	200 psig	200 psig	200 psig	200 psig
Safety Devices					
Pressure Relief Valve	230 psig (16 bar/1586 kPa)	230 psig (16 bar/1586 kPa)	230 psig (16 bar/1586 kPa)	230 psig (16 bar/1586 kPa)	230 psig (16 bar/1586 kPa)
Inner Container Bursting Disc	360 psig (24.8 bar/248 kPa)	360 psig (24.8 bar/248 kPa)	360 psig (24.8 bar/248 kPa)	360 psig (24.8 bar/248 kPa)	360 psig (24.8 bar/248 kPa)
Weight of Contents Based on DOT Rated Service Pressure					
Oxygen	388 lb. (176 kg)	416 lb. (189 kg)	454 lb. (206 kg)	539 lb. (244 kg)	606 lb. (275 kg)
Nitrogen	273 lb. (124 kg)	293 lb. (133 kg)	319 lb. (145 kg)	380 lb. (172 kg)	426 lb. (193 kg)
Argon	471 lb. (214 kg)	505 lb. (229 kg)	551 lb. (250 kg)	655 lb. (297 kg)	735 lb. (333 kg)
Carbon Dioxide	N/A	N/A	N/A	N/A	N/A
Nitrous Oxide	N/A	N/A	N/A	N/A	N/A
Gaseous Capacity Based on DOT Rated Service Pressure @ NTP (STP)					
Oxygen	4688 cu.ft. (123 cu.m)	5025 cu.ft. (132 cu.m)	5484 cu.ft. (144 cu.m)	6511 cu.ft. (171 cu.m)	7320 cu.ft. (207 cu.m)
Nitrogen	3771 cu.ft. (99 cu.m)	4043 cu.ft. (106 cu.m)	4402 cu.ft (116 cu.m)	5244 cu.ft. (139 cu.m)	5879 cu.ft. (166 cu.m)
Argon	4558 cu.ft. (120 cu.m)	4884 cu.ft. (128 cu.m)	5331 cu.ft. (140 cu.m)	6335 cu.ft. (166 cu.m)	7112 cu.ft. (201 cu.m)
Carbon Dioxide	N/A	N/A	N/A	N/A	N/A
Nitrous Oxide	N/A	N/A	N/A	N/A	N/A

(1) - Vented N.E.R. based on usable liquid capacity
(2) - Container pressure at or above factory dual pressure/economizer regulator setting
(3) - Regulator has a pressure delta of 20 psig (1.4 bar/138 kPa)

Specifications subject to change without notice

Accessories

TRANSFER HOSES

Transfer hoses are constructed of a flexible stainless steel suitable for the transfer of cryogenic fluids and are available in 4 ft. (1.2 m) or 6 ft. (1.8 m) lengths. Hoses are fitted with a 3/8 in. NPT male fitting on one end and a CGA female fitting on the other end.

Female End Fitting	Hose Length	Male End Fitting	Part Number
Nitrogen and Argon LIQUID or VENT Connection			
CGA 295	4 ft. (1.2 m)	3/8 in. NPT	1700-9C65
CGA 295	6 ft. (1.8 m)	3/8 in. NPT	1600-9C66
Nitrogen and Argon USE Connection			
CGA 580	6 ft. (1.8 m)	3/8 in. NPT	GL50-8C51
Oxygen LIQUID or VENT Connection			
CGA 440	6 ft. (1.8 m)	3/8 in. NPT	GL50-8C53
Oxygen USE Connection			
CGA 540	6 ft. (1.8 m)	3/8 in. NPT	GL50-8C56
Carbon Dioxide LIQUID or Gas USE Connection			
CGA 320	6 ft. (1.8 m)	3/8 in. NPT	HP50-8C51
Carbon Dioxide Gas VENT Connection			
CGA 295	4 ft. (1.2 m)	3/8 in. NPT	1700-9C65
CGA 295	6 ft. (1.8 m)	3/8 in. NPT	1600-9C66

CRYOGENIC PHASE SEPARATORS

Designed to minimize hazardous splashing and vaporization, phase separators are available in three different sizes to accommodate transferring liquids into various open containers. The two larger phase separator are designed to fit the 3/8 in. NPT end of Taylor-Wharton transfer hoses. Specify quantity and size or part number.

Model	Part No.
2 3/4 in. x 1 3/8 in. OD (3/8 in. NPT) (70 mm x 35 mm)	1193-8C80
1 1/4 in. x 1 in. OD (3/8 in. NPT) (32 mm x 25.4 mm)	1193-8C82
1 1/4 in. x 1/2 in. OD (1/8 in. NPT) (32 mm x 12.7 mm)	1193-8C83

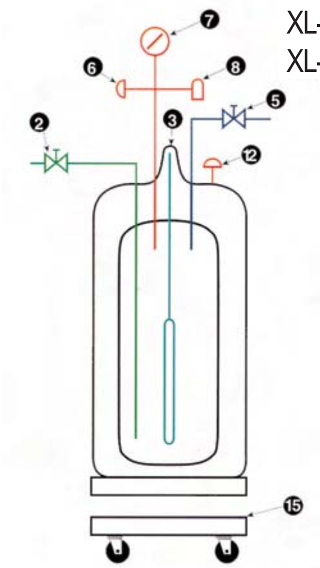
EXTERNAL HEAT EXCHANGER

An External Heat Exchanger (vaporizer effectively increases the gaseous delivery rate of any liquid cylinder by approximately 250 cfh (7.0 cu. m/h) air gases and 120 cfh (3.4 cu m/h) CO_2 continuous at pressures up to 500 psig (34 bar/3447 kPa). The vaporizer is cleaned for oxygen service and comes equipped with a 3/8 in. NPT fitting to connect to a transfer hose and regulator suited to your application. Dimensions - 12 x 15 3/4 x 46

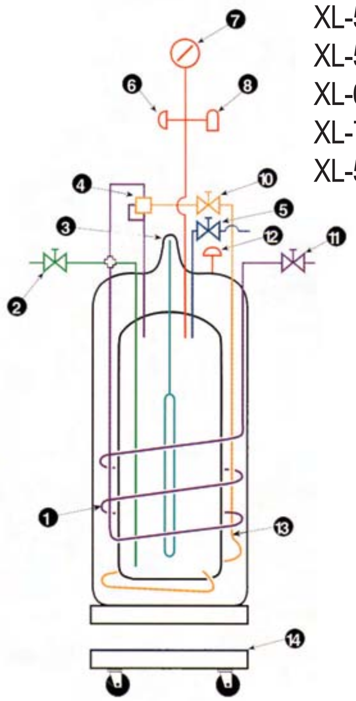
Model	Part No.
External Heat Exchanger	VP50-7C10

Flow Diagram

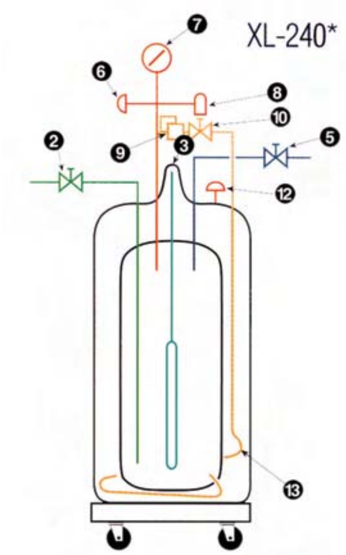
XL-100
XL-160
XL-240



XL-45/45HP
XL-50/50HP
XL-55/55HP
XL-65/65HP
XL-70/70HP
XL-50VHP



XL-240*

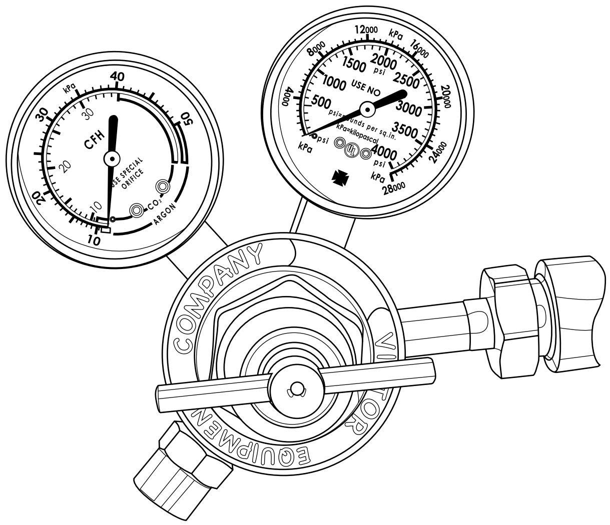


- Safety
- Vent
- Liquid Withdrawal
- Contents Gauge
- Economizer & Gas Use
- Pressure Building*

* Diagram shows XL-240 with pressure building system. XL-240 model also available without this feature.

1. Vaporizer
2. Liquid Fill/Withdrawal Valve
3. Contents Gauge
4. Dual Pressure Building/ Economizer Regulator
5. Vent Valve
6. Inner Containing Bursting Disc
7. Pressure Gauge
8. Pressure Relief Valve
9. Pressure Building Regulator
10. Pressure Building Valve
11. Gas Withdrawal (USE) Valve
12. Vacuum Bursting Disc
13. Pressure Building Coil
14. Base for XL-65/65HP, XL-70/70HP only, optional five-caster base or four-caster base with SureGrip handle available.
15. Five-caster base for XL-100 and XL-240.

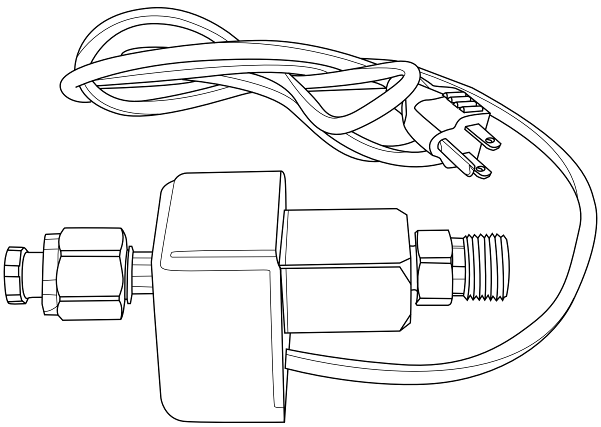
Taylor-Wharton



SAMPLE ORDERING INFORMATION

Model No.	CGA Inlet Connection
AF 250	**580**

Gas Service	Model No.	Part No.	Flow Range (SCFH)	CGA Inlet Connection
Argon	AF 250-580	**0781-0350**	10-40	580
CO_2	CF 253-320	**0781-0351**	7-35	320
Outlet Connection: 5/8"-18 RH(F), CGA 032				



Part No.	Description	Weight	
5370-7141	Electric CO_2 Heater	2 lb.	0.9kg
5370-7142	Electric N_2O Heater	2 lb.	0.9kg

AF 250 & CF 253 Series

- Medium duty
- Ideal for MIG / TIG applications where a flow meter is not necessary or impractical
- Designed for small to medium diameter MIG applications - 0.025" (0.6mm) to 0.045" (1.1mm) wire

Dimensions: ....6.38" W x 5.13" H x 4.25" D
(162.1mm x 130.3mm x 108.0mm)

Weight: ....2 lb. 15 oz. (1.33kg)

DESIGN/CONSTRUCTION

- Forged brass body & housing cap
- 2" (50.8mm) gauges - brass
- Stem type seat mechanism
- 1.75" (44.5mm) diaphragm- fabric reinforced neoprene
- Delrin cap bushing for smooth adjustments
- Internal self reseating relief valve. Not designed to protect downstream equipment.
- Sintered inlet filter - bronze
- Outlet connection 0950-0120

If flow is shut off or restricted downstream of the regulator, the flow gauge will show indicated flow even though there is none.

WARNING: High gas withdrawal rates may cause regulator to freeze up and will require cylinder manifolding. Consult your gas supplier.

A regulator equipped with a flow gauge is not accurate when a back pressure in excess of 2 PSIG exists at the outlet. Back pressure is caused by a restriction in the equipment downstream of the flow gauge.

Metering valves, kinked hoses or even very long hoses are restrictions that can cause back pressure. In applications where back pressure in excess of 2 PSIG can be expected, a regulator equipped with a flow meter should be used.

Gas Heaters: See Chart, single stage, manufactured for either Carbon Dioxide (CO_2) or Nitrous Oxide (N_2O).

Gas Heaters

Manufactured for either Carbon Dioxide (CO_2) or Nitrous Oxide (N_2O). These heaters operate on 110 Volts at 120 Watts and 1 Amp. They are thermostatically controlled at 160°F (+5°) and rated for flows up to 160 SCFH. Rated for standard cylinder pressures up to 3000 PSI.

Sweetwater® Air Diffusers

As close to perfect as diffusers get!
Sweetwater® diffusers are the highest-quality ceramic-type air diffusers on the market today. They're machined from a solid block of glass-bonded silica. Because dust and dirt particles up to 30 microns in size will pass right through these diffusers, there's no need for expensive air filters. And with an air resistance of less than .25 psi, Sweetwater® glass-bonded diffusers are compatible with economical low-pressure blowers.
They produce a uniform medium/fine bubble and are very resistant to clogging. And when cleaning does become necessary because of a buildup of calcium precipitate or bacteria, an acid bath restores them to like-new performance. Two-year guarantee. Made in USA.

Sweetwater®: The Best
With their round grain pore structure, low resistance to airflow, uniform porosity and resistance to clogging, Sweetwater® diffusers are clearly the best diffusers available for general aquaculture aeration.

Smaller pores don't necessarily produce smaller bubbles. Sweetwater® diffusers are engineered to produce the smallest bubble possible within the constraints of a reasonable service life. In most soft water applications, they won't need to be cleaned for more than a year. Note that water pH in excess of 9.0 will shorten the diffuser life. Self-weighting when used with typical tubing lengths.

Beware of Imitations
Sweetwater® diffusers are the original 2,000ºF glass-bonded silica diffusers introduced by AES in 1978. You may come across other diffusers that copy our sizes, descriptions and even our photos! But it takes more than flattering imitation to compete with the best. Look for the name and the two-year warranty.

Compare Closely
Buy one Sweetwater® brand and one Brand X and compare for diffusion uniformity and bubble size—the most important qualities of a diffuser. Also compare pressure, clogging rate and cleaning ability. Many of our customers are still using the same Sweetwater® diffusers they bought 12 years ago!

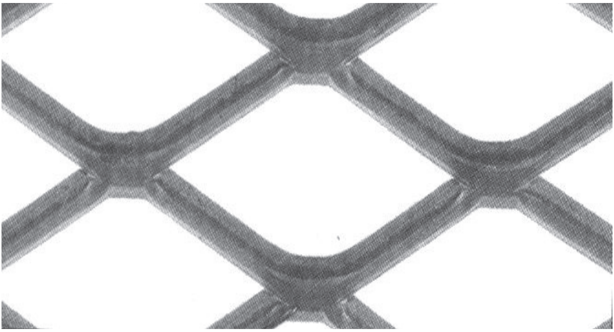
	*Length **		*Width **		*Suggested*			
	in	*cm*	*in*	*cm*	*cfm*	aes	*Air Supply Connection*	*Actual Wt*
AS1	1.5	4	.50	1.3	.05	1.5	3/16" O.D. (4 mm), ABS	.03 lb
AS2	1.5	4	.75	2	.10	3	3/16" O.D. (4 mm), ABS	.06 lb
AS3	2.0	5	1.0	2.5	.20	5	3/16" O.D. (4 mm), PE	.10 lb
ALS3	2.0	5	1.0	2.5	.20	5	1/4" NPT, PE	.10 lb
AS4	1.5	4	1.5	4	.25	7	3/16" O.D. (4 mm), PE	.21 lb
AS5S	3.0	8	1.0	2.5	.30	8	3/16" O.D. (4 mm), PE	.16 lb
AS5L	3.0	8	1.0	2.5	.30	8	1/4" O.D. (6 mm), PE	.16 lb
ALS5	3.0	8	1.0	2.5	.30	8	1/4" NPT, PE	.16 lb
AS8S	3.0	8	1.5	4	.35	10	3/16" O.D. (4 mm), PE	.39 lb
AS8L	3.0	8	1.5	4	.35	10	1/4" O.D. (6 mm), PE	.39 lb
ALS8	3.0	8	1.5	4	.35	10	1/4" NPT, PE	.39 lb
ALR8	3.0	8	1.5	4	.35	10	1/2" NPT, PE	.39 lb
AS15S	6.0	15	1.5	4	.50	14	1/4" O.D. (6 mm), PE	.75 lb
AS15L	6.0	15	1.5	4	.50	14	3/8" O.D. (9 mm), PE	.75 lb
ALR15	6.0	15	1.5	4	.50	14	1/2" NPT, PE	.75 lb
AS23S	9.0	23	1.5	4	.75	20	1/4" O.D. (6 mm), PE	1.35 lbs
AS23L	9.0	23	1.5	4	.75	20	3/8" O.D. (9 mm), PE	1.35 lbs
ALR23	9.0	23	1.5	4	.75	20	1/2" NPT, PE	1.35 lbs
AS30S	12.0	30	1.5	4	1.00	27	1/4" O.D. (6 mm), PE	1.50 lbs
AS30L	12.0	30	1.5	4	1.00	27	3/8" O.D. (9 mm), PE	1.50 lbs
ALR30	12.0	30	1.5	4	1.00	27	1/2" NPT, PE	1.50 lbs
ASW88S**	3.0	8	3.0	8	.70	19	1/4" O.D. (6 mm), PE	.70 lb
ASW88L**	3.0	8	3.0	8	.70	19	3/8" O.D. (6 mm), PE	.70 lb

*Dimensions of length and width are ±1/8" (3 mm). **Fitting is in center of 3" x 3" dimension. The suggested cfm shown above is typical for aquaculture; higher cfm amounts will create larger bubbles. Nonstandard fittings are available on request. PE is high density linear polyethylene. ABS is green plastic.

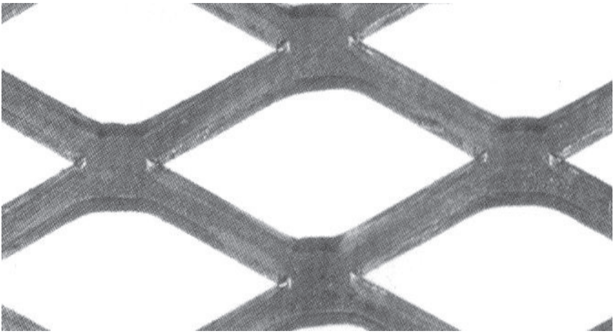
EXPANDED METAL

Expanded metal is a sheet metal that has been slit and expanded to form a diamond shape pattern. While the sheet may be expanded up to ten times its original width and lose up to 80% of its weight, the expanded metal sheet is stronger and more rigid than the original sheet. Expanded metal is available in a regular (raised) pattern, and a flattened pattern. This material is suitable for a vast number of applications where protection, reinforcement, greater strength with less weight, free passage of air and light, and a decorative or ornamental effect are required. Stocked in carbon steel; also available in aluminum, stainless steel and galvanized.

Standard (Raised)



Flattened



Stock sizes - 48″ x 96″
Other widths and lengths are available; please inquire.

STANDARD (RAISED) EXPANDED METAL

* Style Designation	Width & Length (Inches)	Thickness of Strand (Inches)	Lbs. Per Sq. Ft.	Lbs. Per Sheet
1/4″ - #20	48 x 96	.036	.86	27.52
1/4″ - #18	48 x 96	.048	1.14	36.48
1/2″ - #20	48 x 96	.036	.43	13.76
1/2″ - #18	48 x 96	.048	.70	22.40
1/2″ - #16	48 x 96	.060	.86	27.52
1/2″ - #13	48 x 96	.092	1.47	47.04
3/4″ - #16	48 x 96	.060	.54	17.28
3/4″ - #13	48 x 96	.092	.80	25.60
3/4″ - #9	48 x 96	.135	1.80	57.60
1 1/2 - #13	48 x 96	.092	.60	19.20
1 1/2 - #9	48 x 96	.135	1.20	38.40
1 1/2 - #6	48 x 96	.198	2.50	80.00

FLATTENED EXPANDED METAL

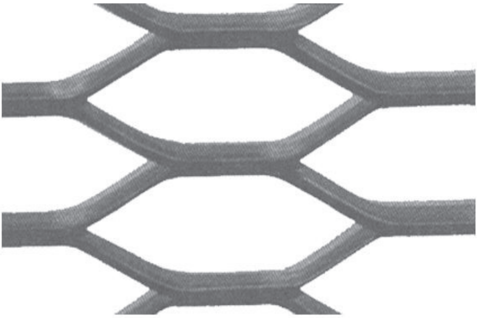
* Style Designation	Width & Length (Inches)	Thickness of Strand (Inches)	Lbs. Per Sq. Ft.	Lbs. Per Sheet
1/4″ - #20	48 x 96	.030	.82	26.24
1/4″ - #18	48 x 96	.040	1.08	34.56
1/2″ - #20	48 x 96	.029	.40	12.80
1/2″ - #18	48 x 96	.039	.66	21.12
1/2″ - #16	48 x 96	.050	.82	26.24
1/2″ - #13	48 x 96	.070	1.40	44.80
3/4″ - #16	48 x 96	.048	.51	16.32
3/4″ - #13	48 x 96	.070	.75	24.00
3/4″ - #9	48 x 96	.120	1.71	54.72
1 1/2 - #13	48 x 96	.070	.57	18.24
1 1/2 - #9	48 x 96	.110	1.14	36.48

Index

EXPANDED METAL GRATING

Grate-X grating is a heavy-duty expanded metal produced from carbon steel sheet and plate. It is structurally stronger than the original plate, yet lightweight. Grate-X is an excellent slip-resistant, low-cost, open flooring.

Expanded metal grating is available in two patterns: grated with the diamonds running the length of the sheet, and walkway (catwalk) with the diamonds running the width of the sheet.



Stock sizes - 48″x 96″

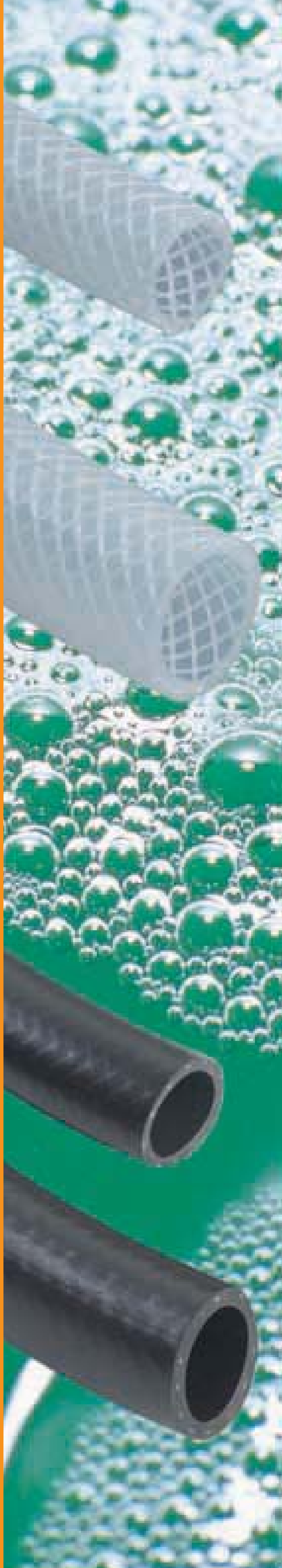
Other widths and lengths are available. Please inquire.

GRATING CHART

* Style Designation (Lbs. Per Sq. Ft.)	Width & Length (Inches)	Thickness of Strand (Inches)	Lbs. Per Sq. Ft.	Lbs. Per Sheet
3.0 lb.	48 x 96	.183	3.0	96.00
3.14 lb.	48 x 96	.250	3.14	100.48
4.0 lb.	48 x 96	.215	4.0	128.00
4.27 lb.	48 x 96	.250	4.27	136.64
5.0 lb.	48 x 96	.250	5.0	160.00
6.25 lb.	48 x 96	.312	6.25	200.00
7.0 lb.	48 x 96	.312	7.0	224.00

Metal Lathe

		Lbs. Per Sq. Yard	
2.5 lb.	27 x 96	2.5	5
1.75 lb.	27 x 96	1.75	3.5



KENTAK D-4100 INDUSTRIAL EVA REINFORCED HOSE

DESIGNED TO TRANSPORT A VARIETY OF CHEMICALS AND LIQUIDS

Profile/Applications:

- Formulated to comply with FDA requirements
- EVA is a high-quality reinforced hose, lightweight & flexible
- Low pressure transfer of chemicals and other liquids

Material/Construction:

- Ethyl Vinyl Acetate inner and outer tube
- Polyester textile yarn reinforcement
- Natural color
- Non reinforced EVA tubing, D-4000 is available as a non stock item *(Call Kentak Sales with your inquiry)*

Operating Temperature Range:

- -30˚ F to +125˚ F

Stock sizes listed below.

EVA INDUSTRIAL EVA REINFORCED HOSE

PART #	I.D	O.D.	WORKING PSI AT 70°F	LENGTH	LBS/CFT
EVA-0140	1/4"	.460"	250 lbs	300 ft	4.8
EVA-0380	3/8"	.594"	250 lbs	300 ft	6.8
EVA-0120	1/2"	.720"	200 lbs	300 ft	8.6
EVA-0580	5/8"	.875"	200 lbs	200 ft	12.0
EVA-0340	3/4"	1.000"	150 lbs	200 ft	14.0
EVA-1000	1"	1.312"	150 lbs	200 ft	23.2
EVA-1140	1-1/4"	1.687"	150 lbs	100 ft	41.1
EVA-1120	1-1/2"	2.000"	150 lbs	100 ft	56.0
EVA-2000	2"	2.437"	150 lbs	100 ft	62.0

Note: As temperature increases the working pressure decreases

KENTAK REINFORCED VINYL WATER HOSE - 165 SERIES

USED FOR STANDARD-DUTY APPLICATIONS WITH CONTRACTORS, GROWERS, EQUIPMENT OPERATORS AND INDUSTRIAL APPLICATIONS

Profile/Applications:

- Reinforced vinyl hose, excellent abrasion resistance
- U.V. and weather resistant
- Transfer of water & mild soluble chemicals
- Standard indent reads: MADE IN USA

Material/Construction/Recommended Couplings:

- Polyvinyl Chloride (PVC) inner and outer tube
- Polyester textile yarn reinforcement
- Black only
- Standard shank fitting couplings with ferrule or clamps

Operating Temperature Range:

- +25˚ F to +150˚ F

Stock sizes listed below.

165 SERIES REINFORCED VINYL WATER HOSE

PART #	I.D	O.D.	WORKING PSI AT 70°F	LENGTH	LBS/CFT
165-0580	5/8"	.825"	150 lbs	250 ft	11.9
165-0340	3/4"	.970"	150 lbs	250 ft	15.6

Note: As temperature increases the working pressure decreases

Submittal Data

PROJECT:	________	UNIT TAG:	________	QUANTITY:	________
	________	TYPE OF SERVICE:	________		________
REPRESENTATIVE:	________	SUBMITTED BY:	________	DATE:	________
ENGINEER:	________	APPROVED BY:	________	DATE:	________
CONTRACTOR:	________	ORDER NO.:	________	DATE:	________

Note! Product picture may differ from actual product

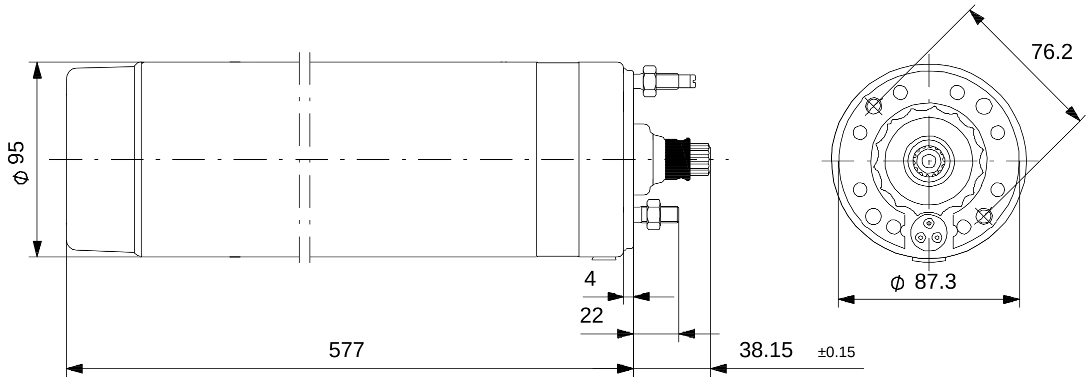
MS 4000

Submersible motors

Conditions of Service	
Flow:	________
Head:	________
Efficiency:	________
Liquid:	________
Temperature:	________
NPSH required:	________
Viscosity:	________
Specific Gravity:	________

Pump Data	
Product number:	96405811

Motor Data	
Rated power - P2:	3.7 kW
Rated voltage:	440-460 V
Mains frequency:	60 Hz
Enclosure class:	IP68
Insulation class:	F
Motor protection:	NONE
Thermal protection:	external
Motor type:	MS4000



Materials:
Motor: Stainless steel
1.4301 EN
AISI 304

Company name:
Created by:
Phone:

Date: 20/02/2018

Tender Text

Note! Product picture may differ from actual product

Product No.: 96405811

MS 4000

The motor is a 3-phase motor of the canned type with sand shield, liquid-lubricated bearings and pressure equalizing diaphragm.

Technical:

Shaft seal for motor:	HM/CER
Motor version:	T40

Materials:

Motor:	Stainless steel 1.4301 EN AISI 304

Installation:

Maximum ambient pressure:	60 bar
Motor diameter:	4 inch

Electrical data:

Motor type:	MS4000
Rated power - P2:	3.7 kW
Mains frequency:	60 Hz
Rated voltage:	3 x 440-460 V
Voltage tolerance:	+6/-10 %
Service factor:	1,15
Rated current:	8,65-8,65 A
Maximum current consumption:	8.65 A
Starting current:	550-590 %
Cos phi - power factor:	0,83-0,80
Rated speed:	3460-3470 rpm
Locked-rotor torque:	170-190 %
Moment of inertia:	0.0022 kg m²
Start. method:	direct-on-line
Enclosure class (IEC 34-5):	IP68
Insulation class (IEC 85):	F
Built-in temp. transmitter:	no
Winding resistance:	4,67 ohm

Others:

Net weight:	24 kg

GRUNDFOS

Company name:
Created by:
Phone:

Date: 20/02/2018

Position	Qty.	Description
	1	**MS 4000**

Note! Product picture may differ from actual product

Product No.: 96405811
The motor is a 3-phase motor of the canned type with sand shield, liquid-lubricated bearings and pressure equalizing diaphragm.

Technical:

Shaft seal for motor:	HM/CER
Motor version:	T40

Materials:

Motor:	Stainless steel 1.4301 EN AISI 304

Installation:

Maximum ambient pressure:	60 bar
Motor diameter:	4 inch

Electrical data:

Motor type:	MS4000
Rated power - P2:	3.7 kW
Mains frequency:	60 Hz
Rated voltage:	3 x 440-460 V
Voltage tolerance:	+6/-10 %
Service factor:	1,15
Rated current:	8,65-8,65 A
Maximum current consumption:	8.65 A
Starting current:	550-590 %
Cos phi - power factor:	0,83-0,80
Rated speed:	3460-3470 rpm
Locked-rotor torque:	170-190 %
Moment of inertia:	0.0022 kg m²
Start. method:	direct-on-line
Enclosure class (IEC 34-5):	IP68
Insulation class (IEC 85):	F
Built-in temp. transmitter:	no
Winding resistance:	4,67 ohm

Others:

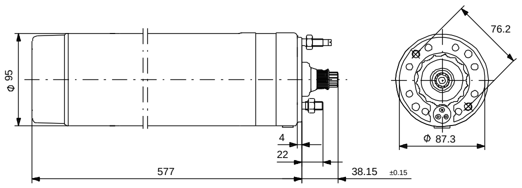
Net weight:	24 kg

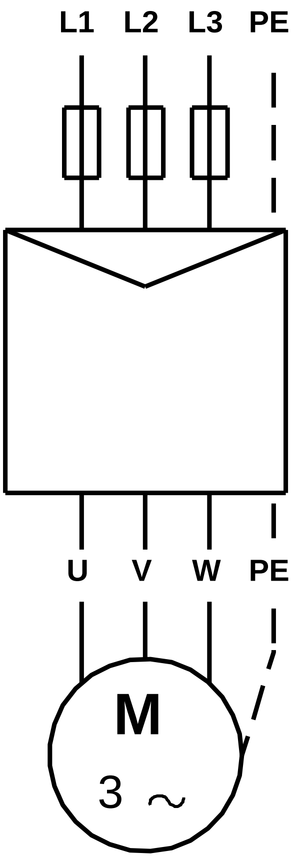
GRUNDFOS

Company name:
Created by:
Phone:

Date: 20/02/2018

Description	Value
General information:	
Product name:	MS 4000
Product No:	96405811
EAN number:	5700391231544
Technical:	
Shaft seal for motor:	HM/CER
Motor version:	T40
Materials:	
Motor:	Stainless steel
	1.4301 EN
	AISI 304
Installation:	
Maximum ambient pressure:	60 bar
Motor diameter:	4 inch
Staybolt:	5/16-24 UNF
Electrical data:	
Motor type:	MS4000
Rated power - P2:	3.7 kW
KVA code:	J
Mains frequency:	60 Hz
Rated voltage:	3 x 440-460 V
Voltage tolerance:	+6/-10 %
Service factor:	1,15
Rated current:	8,65-8,65 A
Maximum current consumption:	8.65 A
Starting current:	550-590 %
Cos phi - power factor:	0,83-0,80
Rated speed:	3460-3470 rpm
Locked-rotor torque:	170-190 %
Moment of inertia:	0.0022 kg m²
Axial load max:	450 kg
Start. method:	direct-on-line
Enclosure class (IEC 34-5):	IP68
Insulation class (IEC 85):	F
Motor protec:	NONE
Thermal protec:	external
Built-in temp. transmitter:	no
Winding resistance:	4,67 ohm
Others:	
Net weight:	24 kg

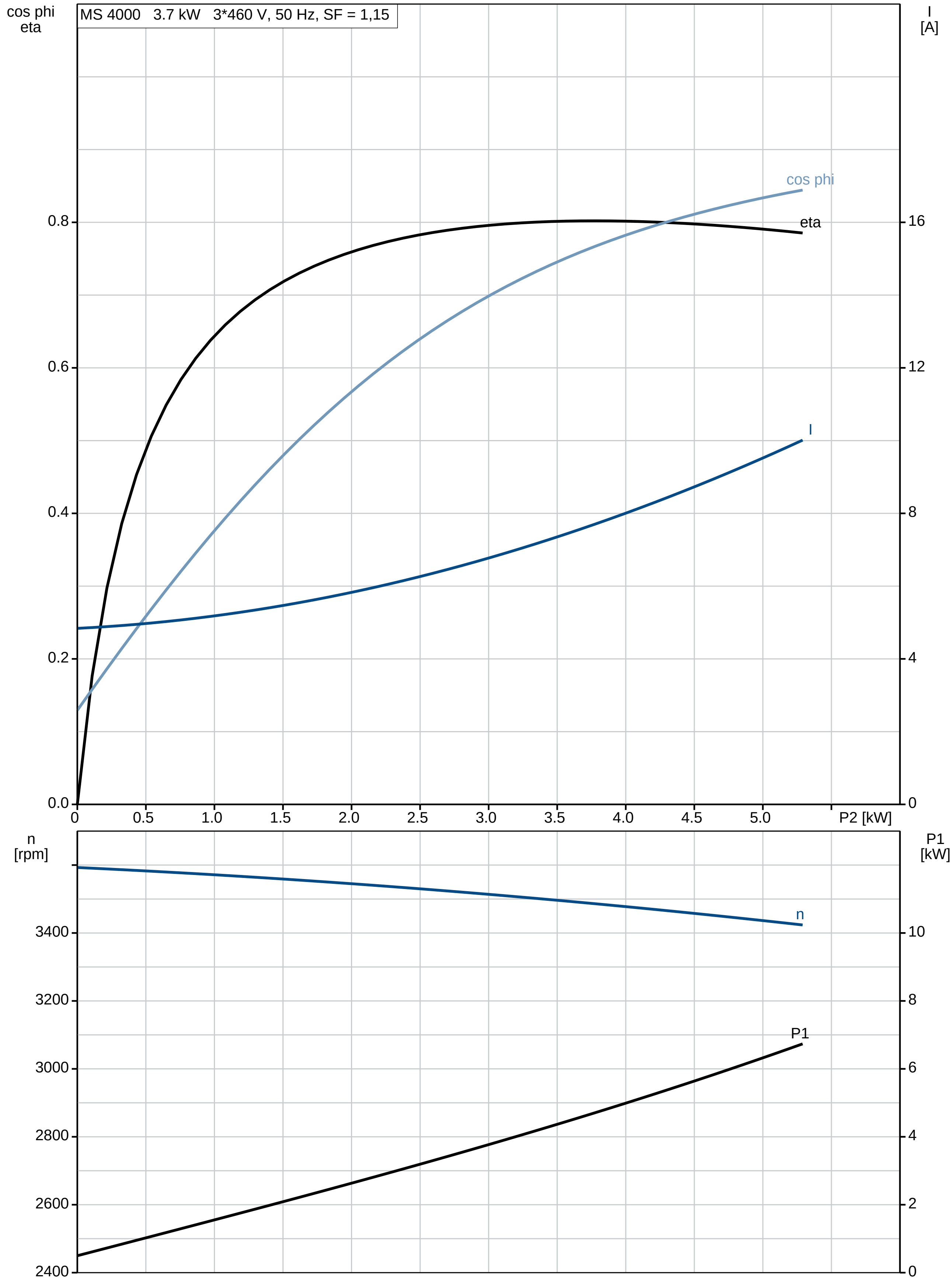




Company name:
Created by:
Phone:

Date: 20/02/2018

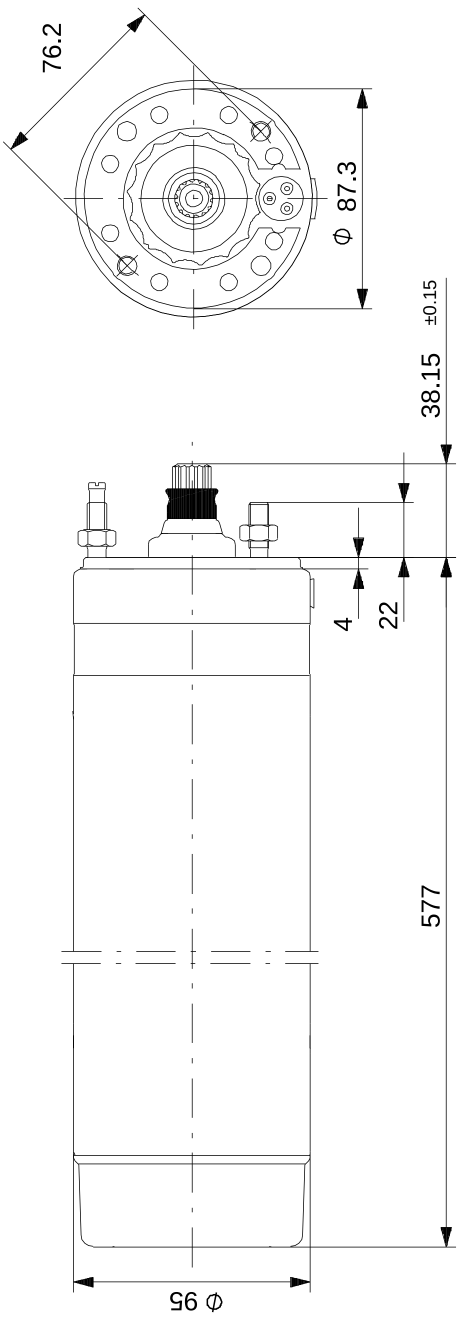
96405811 MS 4000 60 Hz



Company name:
Created by:
Phone:

Date: 20/02/2018

96405811 MS 4000 60 Hz

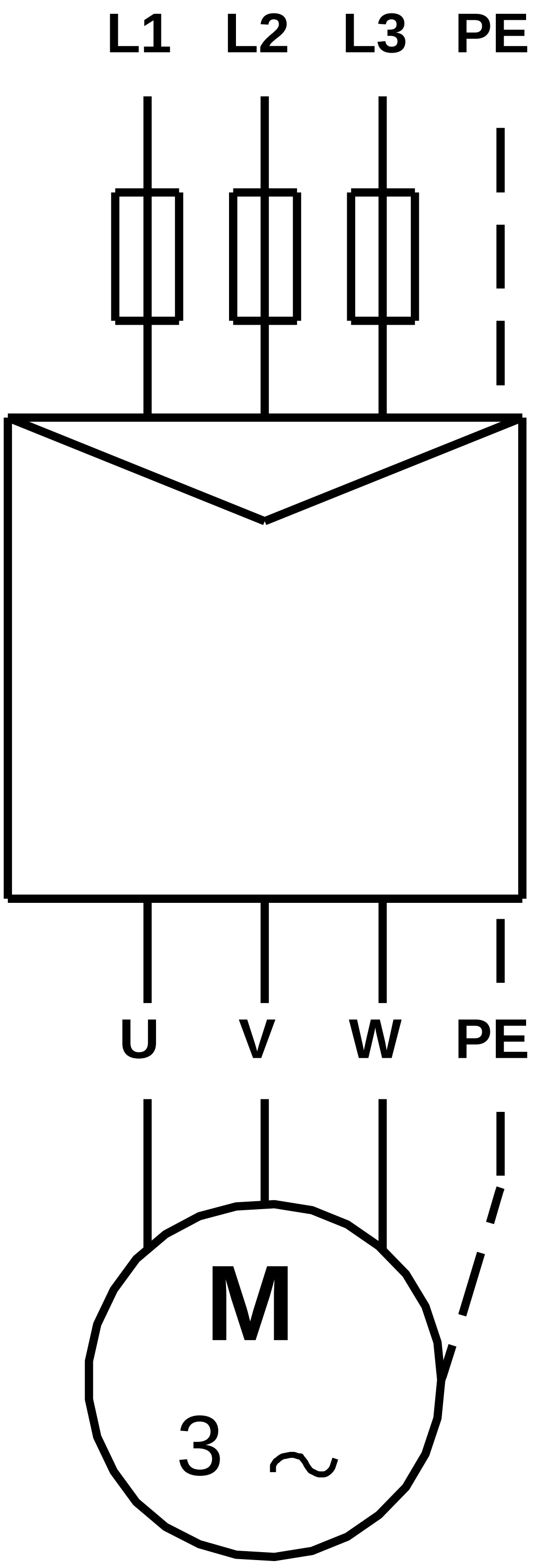


Note! All units are in [mm] unless others are stated.
Disclaimer: This simplified dimensional drawing does not show all details.

Company name:
Created by:
Phone:

Date: 20/02/2018

96405811 MS 4000 60 Hz



Note! All units are in [mm] unless others are stated.

Company name:
Created by:
Phone:

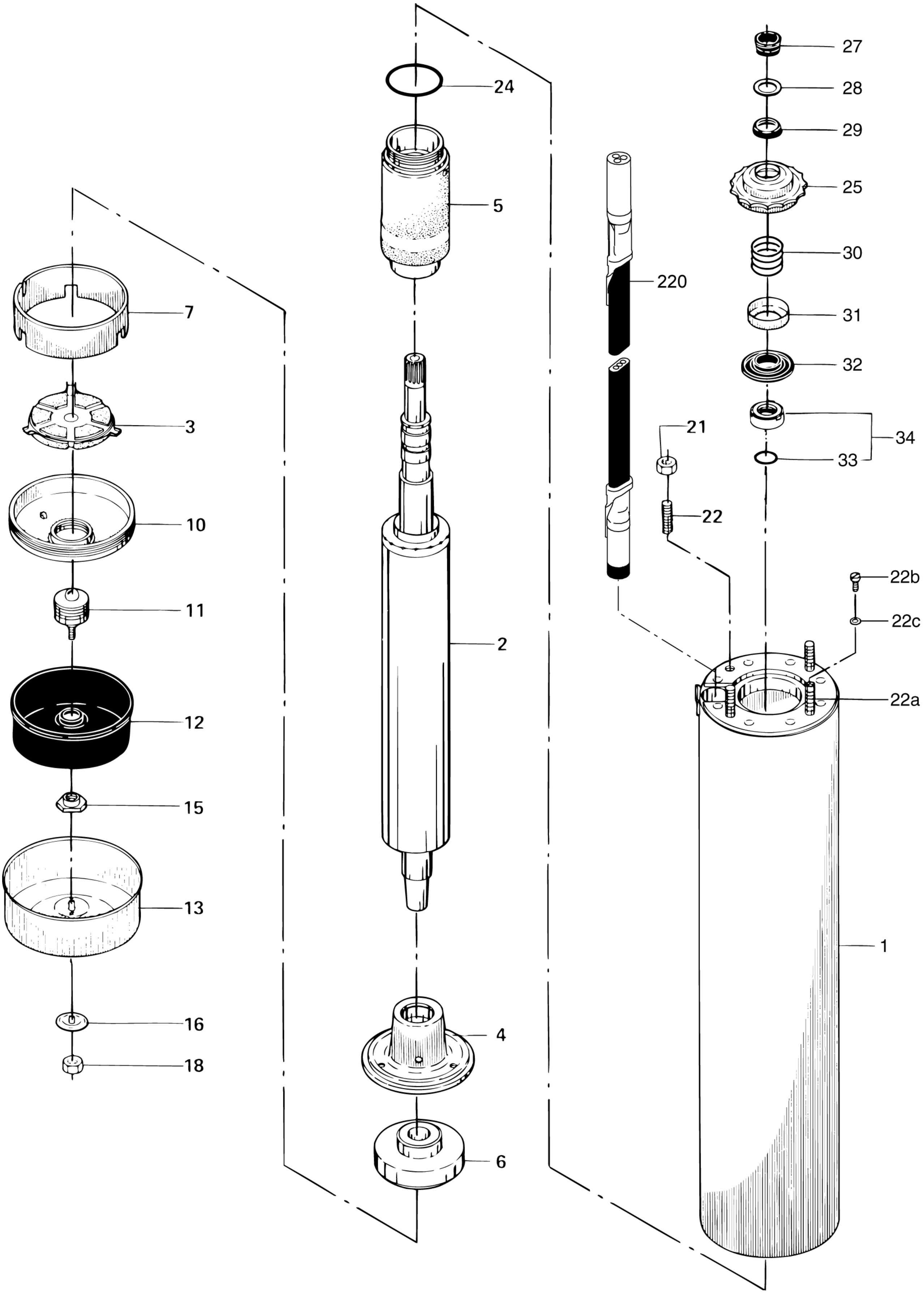
Date: 20/02/2018

Order Data:

Product name: MS 4000
Amount: 1
Product No: 96405811

Total: Price on request

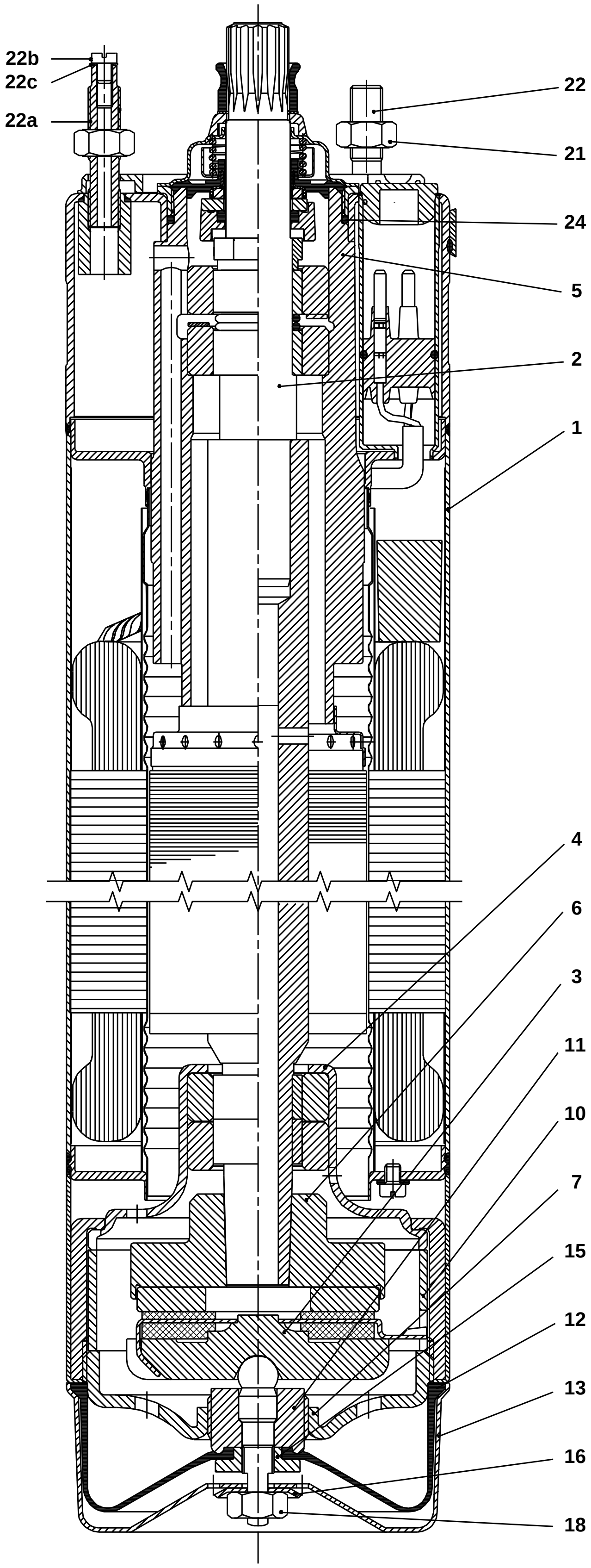
Exploded view



Company name:
Created by:
Phone:

Date: 20/02/2018

Sectional drawing



GRUNDFOS

Company name:
Created by:
Phone:

Date: 20/02/2018

Parts list MS 4000, Product No. 96405811
Valid from 18.4.1995 (9516)

Pos	Description	Annotation	Classification Data	Part no.	Qty.	Unit
-	Motor				1	pcs
1	Stator				1	
2	Shaft w/rotor				1	
3	Thrust ring support cpl.				1	
4	Radial bearing				1	
5	Bearing pipe				1	
6	Thrust bearing				1	
7	Lock ring				1	
10	Bearing retainer				1	
11	Adjusting screw				1	
12	Diaphragm				1	
13	End shield				1	
15	Nut				1	
16	Lock washer				1	
18	Nut		Thread: M8		1	
21	Hex nut		Thread: 5/16"		4	
22	Staybolt				4	
22	Staybolt				4	
22b	Cheese head screw				1	
22c	O-ring		Diameter: 4		1	
			Material type: NBR			
			Thickness: 1			
24	O-ring		Diameter: 40		1	
			Material type: NBR			
			Thickness: 2			
25	Shaft seal housing				1	
27	Spline protector				1	
28	Support				1	
29	Sand shield				1	
30	Compression spring				1	
31	Supporting ring				1	
32	Sleeve				1	
34	Shaft seal cpl.				1	
20	Motor cable				1	pcs

PHASE TECHNOLOGIES

SD SERIES 2XD SERIES Specifications
SD | 2XD Models

MADE IN U.S.A.

Phase Converting VFDs

Designed specifically for pumping

Phase Technologies has designed a simple, phase converting solution for residential and light commercial constant pressure installations (2-10hp). The SD product line offers simple setup, rugged hardware, 3R cabinets, and a top of the line oil filled pressure transducer standard with every package.

Description

Return trips are expensive and can many times lead to a poor customer image of the installation. Phase Technologies has produced a product line specifically to solve this problem, the SD series. With pricing that even the most budget minded customer will appreciate and 3 year warranty the SD series is the best choice for small constant pressure applications.

Demand-driven constant pressure for home wells is now inexpensive, reliable, and a luxury available to all homeowners thanks to Perfect Pressure, standard with all SD and 2XD systems. Perfect Pressure only requires a few minutes of setup time and is capable of controlling the most complicated plumbing systems with ease. With constant pressure, plumbing systems run smoothly with fewer instances of short cycling.

231 East Main St. North, Rapid City, SD 57701
605-343-7934 Main   866-250-7934 Toll Free

SD-2XD Series Variable Frequency Drives

Features		
NEMA Type 3R Outdoor Enclosure **Optional Integrated Output Filters** **Motor Protection** • Broken Pipe Detection • Short Cycle Protection • Overcurrent Protection • Dry Well Protection	**Constant Pressure** • PSI Boost • Pipe Pre-Charge • Duplex Control • Triplex Control Lead Lag/Pump Staging • Multiple Pressure Setpoints	**Automatic Restarts** **Restart Delay** **Run/Stop Control** **Password Protection** **Programmable Relays** **Real Time Clock** **Fault log**

Keypad

Our setup is simple for constant pressure with the Perfect Pressure® wizard. Our systems have a clear and easy-to-read screen with clear language for alert messages.

SD-2XD Series Variable Frequency Drives

Nomenclature

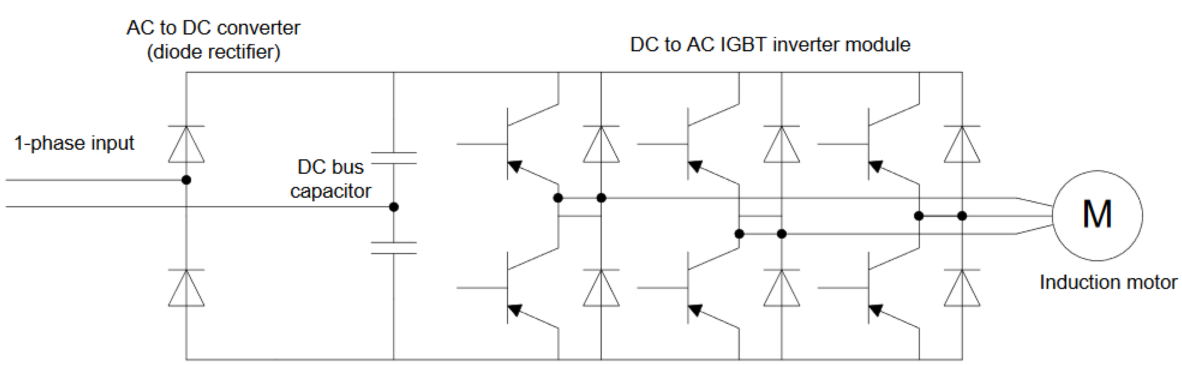
SD Series — *Part Number Examples: SD002R-S, SD405R-O* — UL508A Panel Shop Integrated Options

Series	Input Voltage	Rated HP	Enclosure Rating	–	Output Filter	Surge Arrestor
SD Phase Converting 240V	0 0 240V	-- 02 - 2 HP 03 - 3 HP 05 - 5 HP 07 - 7.5 HP 10 - 10 HP	R 3R Rated Outdoor Type Rain / Bug Proof	–	-- *Not Available*	S Strikesorb Surge Arrestor *Available Only: SD007 SD010
SD Phase Converting 480V	4 4 480V	-- 05 - 5 HP 07 - 7.5 HP 10 - 10 HP	R 3R Rated Outdoor Type Rain / Bug Proof	–	O Sine Wave Ouput Filter	-- Not Available

2XD SERIES — Part Number Example: 2XD205R-OS — UL508A Panel Shop Integrated Options

Series	Input Voltage	Rated HP	Enclosure Rating	–	Output Filter	Surge Arrestor
2XD Phase Converting & Voltage Doubling	2 2 240V (Voltage Doubling)	05 05 - 5 HP 07 - 7.5 HP 10 - 10 HP	R 3R Rated Outdoor Type Rain / Bug Proof	–	O Sine Wave Filter	S Strikesorb Surge Arrestor
		15 15 - 15 HP	R 3R Rated Outdoor Type Rain / Bug Proof	–	OF dV/dt Filter	S Strikesorb Surge Arrestor

Block Diagram



PHASE TECHNOLOGIES

SD-2XD Series Variable Frequency Drives

Current Ratings | Weight | Dimensions

SD Series

Model / Part Number	HP	Input Rated Amps	Output Rated Amps	Weight	Max Dimensions (W x H x D) Inches
240V Input Single-Phase | 240V Output Three-Phase					
SD002	2HP	19A	9A	15 lbs	14 x 20 x 7 in.
SD003	3HP	29A	11A	16 lbs	14 x 20 x 7 in.
SD005	5HP	42A	20A	17 lbs	14 x 20 x 7 in.
SD007	7.5HP	58A	27A	17 lbs	19 x 28 x 13 in.
SD010	10HP	69A	33A	19 lbs	19 x 28 x 13 in.
480V Input Single-Phase | 480V Output Three-Phase					
SD405	5HP	29A	10A	16 lbs	21 x 33 x 10 in.
SD407	7.5HP	32A	13A	17 lbs	21 x 33 x 10 in.
SD410	10HP	42A	18A	19 lbs	21 x 33 x 10 in.

2XD Series

Model / Part Number	HP	Input Rated Amps	Output Rated Amps	Weight	Max Dimensions (W x H x D) Inches
240V Input Single-Phase | 480V Output Three-Phase					
2XD205	5HP	31A	10A	15 lbs	22 x 33 x 13 in.
2XD207	7.5HP	52A	13A	17 lbs	22 x 33 x 13 in.
2XD210	10HP	64A	18A	18 lbs	22 x 33 x 13 in.
2XD215	15HP	87A	24A	25 lbs	22 x 33 x 13 in.

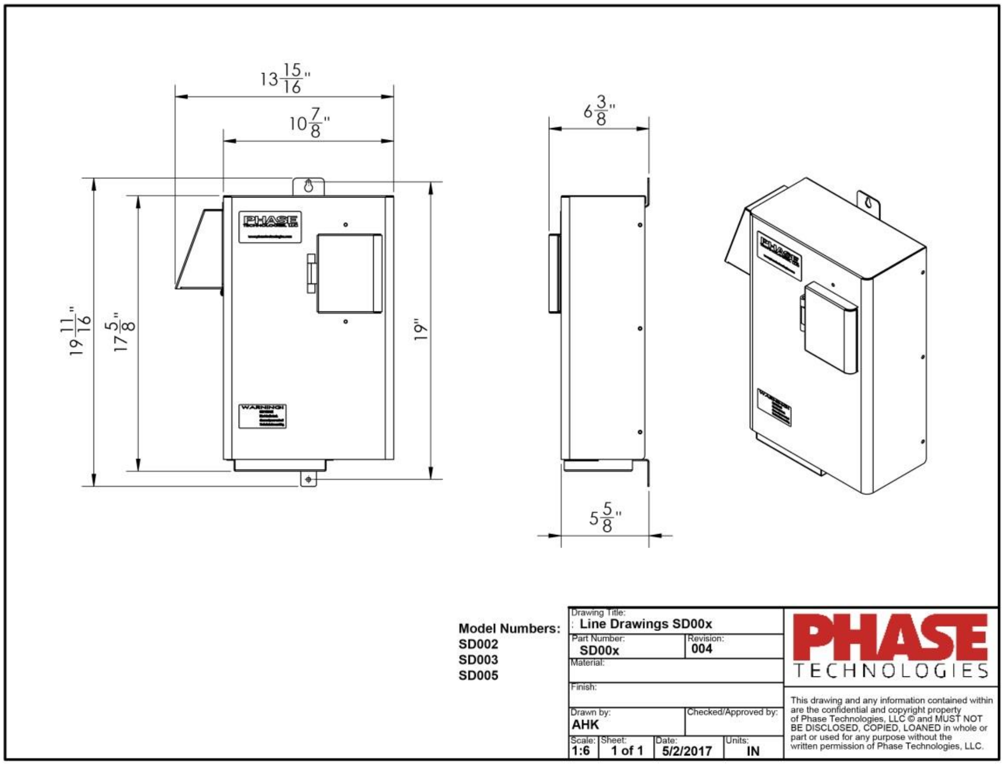
508A Panel Shop Options

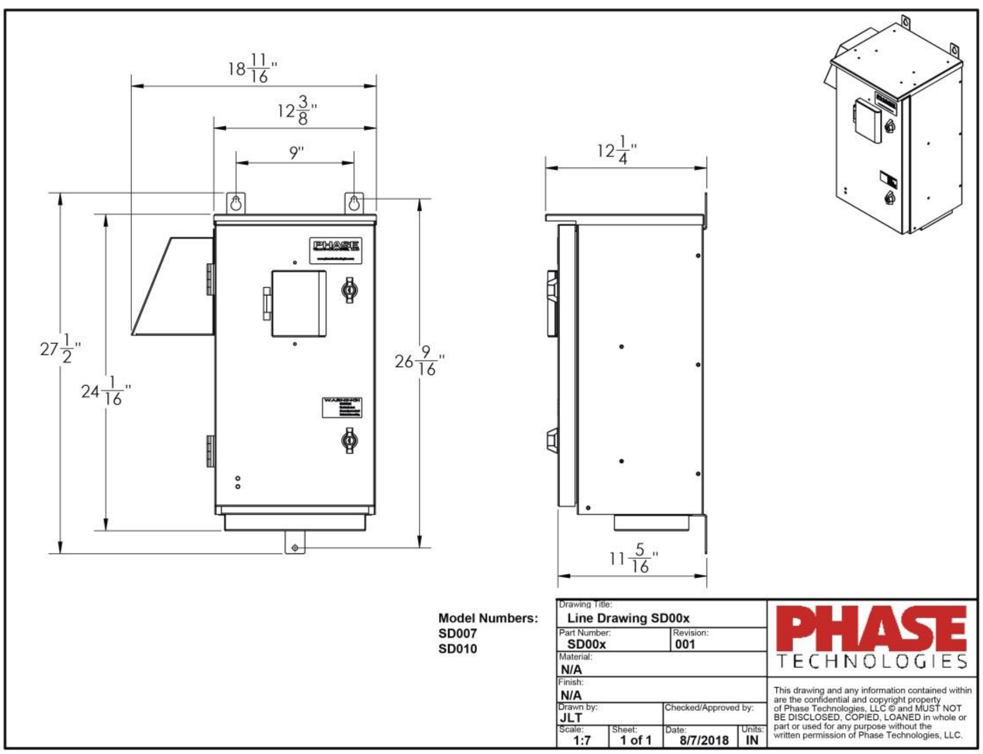
Sinewave Filter

dV/dT Filter

SD Series Variable Frequency Drives
Line Drawings

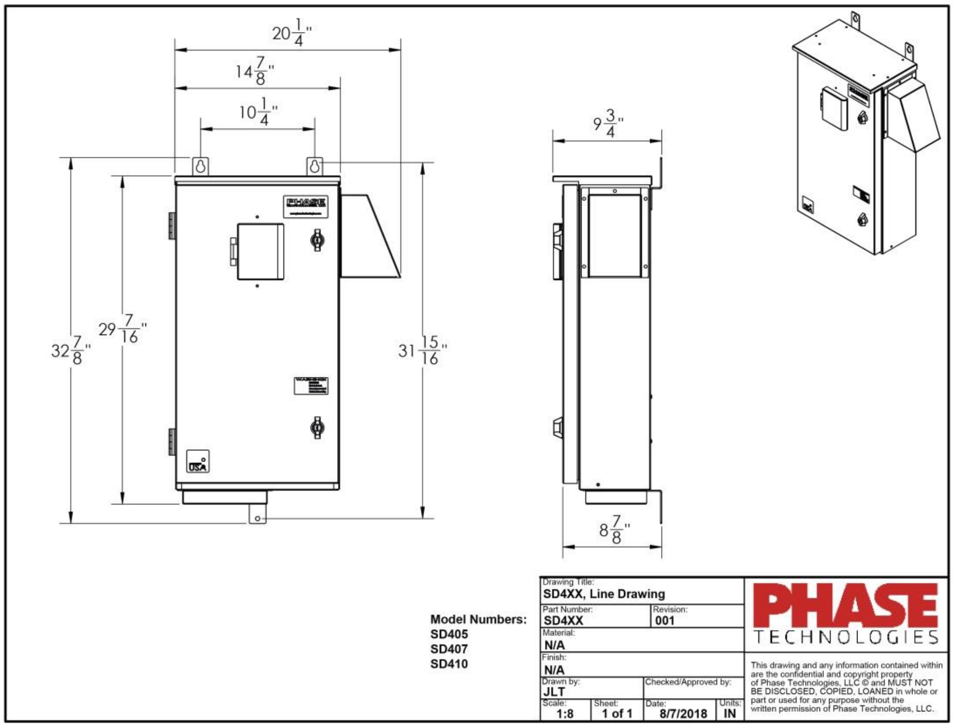
SD Models



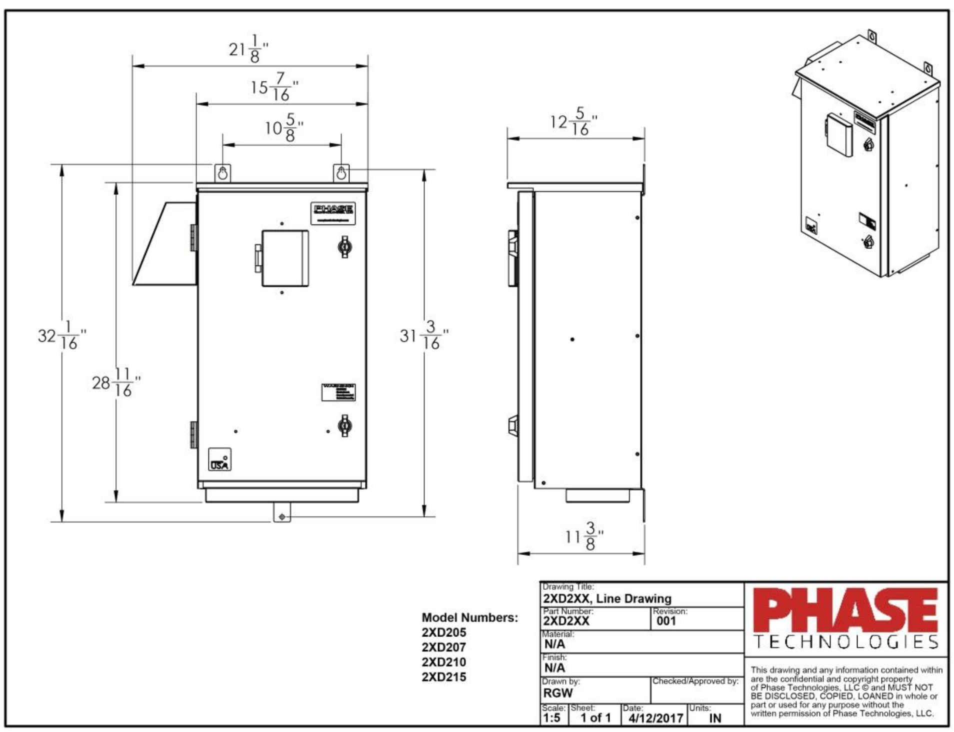


SD-2XD Series Variable Frequency Drives

SD Models



2XD Models



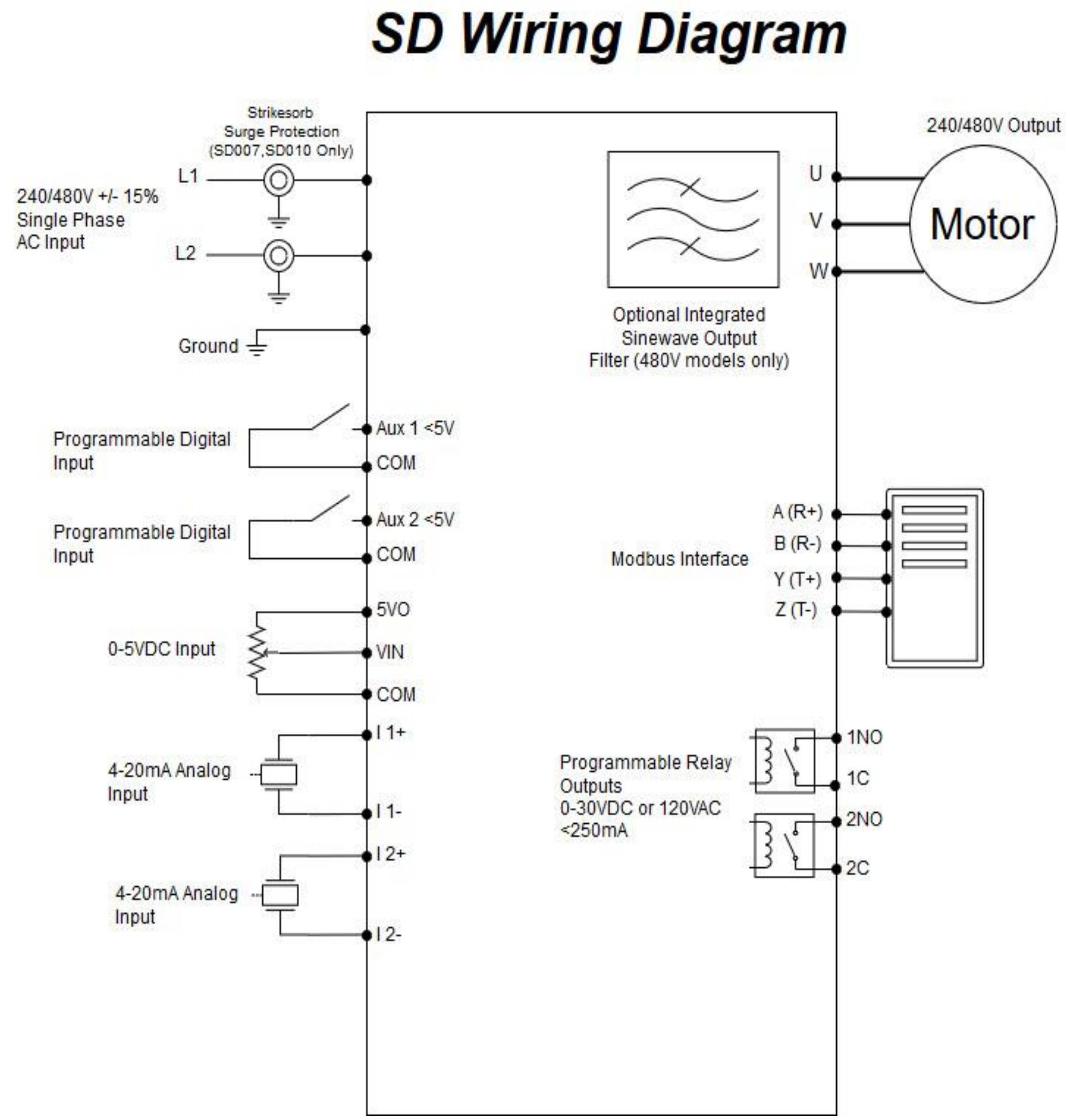
SD Series Variable Frequency Drives

Specifications

Physical/Environmental	
Operating Temperature Range	-10C to 50C
*Heater in enclosure may be required below -40C, de-rating required above 50 C.	
Ambient Temperature Range	-40C to +50C
Enclosure	NEMA 3R
Altitude	Derate by 5°C every 2000ft over 5500ft of elevation
Input Power	
Input Phase	1 phase
Input voltage range	180-260V or 430-520V
Input frequency	60 Hz
Output Power	
Output Phase	3 phase
Output Frequency	5-300Hz
Output Voltage	240V or 480V
Output	V/F control
Horse Power	2,3,5, 7.5, 10
Switching frequency	2kHz-8kHz
Integrated Output Filter	Optional Sinewave 5-10HP in 480V models
Electrical	
Short Circuit Withstand Rating	5kA RMS symmetrical amperes
Efficiency	95%
Startup Ramp Time	0-120s
Shutdown Ramp Time	0-120s or Coast to Stop
Overload Capacity	150% for 2s
Rated output current for 5-15HP models based on typical full load current for submersible motors.	
Analog Inputs	
Quantity	Three Programmable
Current Reference	4-20mA, Two Inputs
Voltage Reference	0-5VDC, One Input
Terminal Block Size	30-16AWG
Relay Outputs	
Quantity	Two Programmable
Capacity	0-30VDC or 120VAC, <250mA
Terminal Block Size	30-16AWG
Digital Inputs	
Quantity	Two Programmable
Capacity	<5 volts, Galvanically Isolated

SD-2XD Series Variable Frequency Drives

Wiring



1.1.6 Levelogger Edge

The Levelogger Edge is an absolute (non-vented) datalogger, which measures groundwater and surface water levels and temperature. Water levels are displayed as temperature compensated pressure readings, and can be barometrically compensated with the aid of a Barologger.

Note: Solinst recommends using the most recent Levelogger Edge firmware version with the latest Levelogger Software version. See Section 2.3.

Levelogger Edge Technical Specifications	
Level Sensor:	Piezoresistive Silicon with Hastelloy Sensor
Ranges:	5, 10, 20, 30, 100, 200 m
Accuracy:	± 0.05% FS
Resolution:	0.001% FS to 0.0006% FS
Normalization:	Automatic Temperature Compensation
Temp. Comp. Range:	0ºC to 50ºC
Temperature Sensor:	Platinum Resistance Temperature Detector (RTD)
Temp. Sensor Accuracy:	± 0.05ºC
Temp. Sensor Resolution:	0.003ºC
Battery Life:	10 years (based on 1 reading/minute)
Clock Accuracy (typical):	± 1 minute/year (-20ºC to 80ºC)
Operating Temperature:	-20ºC to 80ºC
Maximum # Readings:	40,000 sets of readings
Memory:	Continuous or Slate mode
Communication Speed:	9600 bps, 38,400 bps with USB optical reader
Com Interface:	Optical Infra-red: USB, RS-232, SDI-12
Size:	22 mm x 159 mm (7/8" x 6.25")
Weight:	129 grams (4.5 oz.)
Corrosion Resistance:	Titanium based PVD coated body and superior corrosion resistant Hastelloy sensor
Other Wetted Materials:	Delrin, Viton, 316L Stainless Steel
Sampling Modes:	Linear, Event & User-Selectable Schedule with Repeat Mode, Future Start, Future Stop, Real Time View
Measurement Rates:	0.125 second to 99 hours
Barometric Compensation:	High accuracy, air-only, Barologger Edge

Models	Full Scale	Accuracy	Resolution
M5	5 m (16.4 ft.)	± 0.3 cm (0.010 ft.)	0.001% FS
M10	10 m (32.8 ft.)	± 0.5 cm (0.016 ft.)	0.0006% FS
M20	20 m (65.6 ft.)	± 1 cm (0.032 ft.)	0.0006% FS
M30	30 m (98.4 ft.)	± 1.5 cm (0.064 ft.)	0.0006% FS
M100	100 m (328.1 ft.)	± 5 cm (0.164 ft.)	0.0006% FS
M200	200 m (656.2 ft.)	± 10 cm (0.328 ft.)	0.0006% FS

1.1.7 Barologger Edge

The Barologger Edge uses algorithms based on air pressure only. It measures and logs changes in atmospheric pressure and temperature, which are then used to compensate water level readings recorded by a Levelogger.

Note: Solinst recommends using the most recent Barologger Edge firmware version with the latest Levelogger Software version. See Section 2.3.

Barologger Edge Technical Specifications	
Level Sensor:	Piezoresistive Silicon with Hastelloy Sensor
Accuracy:	± 0.05 kPa
Resolution:	0.002% FS
Normalization:	Automatic Temperature Compensation
Temp. Comp. Range:	-10ºC to 50ºC
Temperature Sensor:	Platinum Resistance Temperature Detector (RTD)
Temp. Sensor Accuracy:	± 0.05ºC
Temp. Sensor Resolution:	0.003ºC
Battery Life:	10 years (based on 1 reading/minute)
Clock Accuracy (typical):	±1 minute/year (-20ºC to 80ºC)
Operating Temperature:	-20ºC to 80ºC
Maximum # Readings:	40,000 sets of readings
Memory:	Continuous or Slate mode
Communication Speed:	9600 bps, 38,400 bps with USB optical reader
Com Interface:	Optical Infra-red: USB, RS-232, SDI-12
Size:	22 mm x 159 mm (7/8" x 6.25")
Weight:	129 grams (4.5 oz.)
Corrosion Resistance:	Titanium based PVD coated body and superior corrosion resistant Hastelloy sensor
Other Wetted Materials:	Delrin, Viton, 316L Stainless Steel
Sampling Modes:	Linear, Event & User-Selectable Schedule with Repeat Mode, Future Start, Future Stop, Real Time View
Measurement Rates:	0.125 second to 99 hours

Model	Full Scale (FS)	Accuracy	Resolution
Barologger (M1.5)	Air Only	±0.05 kPa	0.002% FS

Why Use Telemetry Systems?

Telemetry systems offer cost savings, flexibility and easy access to remote monitoring locations.

Advantages

- Frequent access to detailed data
- Long term cost savings
- Time saved by eliminating manual data collection
- No need for regular travel to remote field locations
- Self-management gives additional savings and data security
- Simple software and easy integration into network

Applications

- Remote water level monitoring
- Long-term drought monitoring
- Management of water taking
- Golf course and mine water management
- Flood and storm water management
- Long-term aquifer management

STS Edge

- GSM digital cellular
- Small to large networks
- Control your own telemetry systems over the web
- Set alarm notifications

RRL

- Short-distance radio
- Small closed loop networks
- Interchangeable stations (ideal for re-configuring your network)
- Compact, all-in-one units

LevelSender

- GSM cellular communication
- Compact design fits inside 2" well
- Simple, low cost option
- Data sent by email or SMS

Built For Solinst Dataloggers

Solinst Telemetry Systems are dedicated for use with Solinst dataloggers. This provides the advantage of combining a user-friendly telemetry system with high quality dataloggers.

Solinst dataloggers are ideal for remote monitoring, with independent user-defined logging schedules as a back-up. They have long battery life, power surge protection and a non-volatile memory. If programmed separately, dataloggers record regardless of the status of the Telemetry System.

Solinst dataloggers are low maintenance. These reliable, durable dataloggers have intuitive software with many useful features, such as self-tests and firmware upgrade and diagnostic utilities.

	LS LevelSender 	STS Telemetry System 	RRL Remote Radio Link 
Specifications	**Cellular (GSM)**	**Cellular (GSM)**	**Radio**
Why Use?	• fits in a 2" (50 mm) well • low cost, simple to use • cellular coverage available • topography not suitable for radio • send data via email and SMS	• cellular coverage available • topography not suitable for radio • send data over the Internet	• smaller applications • closed loop network at any location • fits in a 4.5” (115 mm) well
System Differences	• monthly carrier fees • no scheduling conflicts for data transmission	• monthly carrier fees • no scheduling conflicts for data transmission • alarm notifications	• free airtime, no long distance fees • you control the network • schedule data transmission times • relay stations to increase coverage
Suggested Applications	• flood and stormwater management • watershed management • drought monitoring	• flood and stormwater management • watershed management • drought monitoring	• monitoring mine sites • agricultural studies • landfill supervision • golf course management
Remote Station Support	• GSM cellular radio module • dynamic IP address • email address	• GSM IP enabled modem • dynamic IP address • 115200 bits/sec	• 900 MHz radio • 9600 bits/sec
Home Station Support	• email address • LevelSender PC Software • no extra hardware	• static IP address • STS/RRL PC Software • no extra hardware	• RRL Home Station radio with power source • STS/RRL PC Software
Datalogger Support	Connect one datalogger, or two using a splitter	Connect up to four dataloggers	Connect up two dataloggers, or up to four using a splitter
Data Transmission	• sent as text to multiple email and an SMS recipient • data from each email/SMS saved as .xle file on the Home Station computer (exported using LevelSender Software) • saved in a database on the Home Station computer (.sqlite file). Database is appended as new data is received	• saved in a database on the Home Station computer (.mbd file). Database is appended as new data is received • data can be exported using STS/RRL Software as .lev, .csv or .xle files • barometric compensation can be done using STS/RRL Software	
Antenna	Cellular SME Male Monopole 2dBi	Dual Band Dipole	6" (15 cm) half wave, (2.1dBi) non-articulating
Typical Coverage			20 mile (30 km) line of site
Optional Antenna	Quad Band, Omni Directional	Quad Band, Omni Directional	5 dBi Omni Directional
Power	3 AA lithium batteries	12V 12-30 AHr deep-cycle, rechargeable sealed lead-acid battery recommended (not included)	6 AA lithium batteries
External Power and Charge Accessories	None	• Solar power connection package (for user supplied solar panel) • AC power/battery charger assembly	
No Data Hosting Fees	√	√	√
Remote Diagnostic Reporting	√	√	√

Printed in Canada
November 6, 2017

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35 Todd Road, Georgetown, Ontario Canada L7G 4R8
Web Site: www.solinst.com E-mail: instruments@solinst.com

DR 2800™ PORTABLE SPECTROPHOTOMETER

Applications

- Drinking Water
- Wastewater
- Power
- Industrial Water
- Environmental Water
- Food and Beverage

Versatile, easy to use and portable.

Hach's most popular portable, known for its versatility and ease of use. Take your analysis where you need it.

More than 240 Analytical Methods and Chemistries

The Hach DR 2800 Portable Spectrophotometer can be used for more than 240 analytical methods, including more than more than 30 TNTplus reagent vial tests that provide innovative bar code labeling for reliable, automatic method detection. The DR 2800 can store up to 50 user programs and 500 data points, including sample and operator ID.

Small Footprint, Large Touch Screen

The DR 2800 is only 8.7 by 13.1 inches, allowing it to fit into any lab while remaining completely portable. The easy-to-use touch screen is intuitive to operate.

Time-Saving Automatic Method Detection and Superior Accuracy

TNTplus reagent vials for selected analytical methods provide automatic method detection, which helps eliminate human error, saving time and money. While rotating the TNT vial, the instrument takes 10 absorbance measurements in less than 5 seconds. The average value is used to calculate the results, providing built-in accuracy. Reagent blanks are unnecessary.

Update the Instrument or Transfer Data Easily

Update DR 2800 spectrophotometer systems and transfer measurement data with a USB memory stick. Two USB ports on the instrument allow it to connect to a computer and to a memory device or hand-held bar code scanner at the same time.

Accommodates Multiple Cell Sizes and Sample Delivery Methods

The DR 2800 spectrophotometer holds eight types of Hach cells. The optional Pour-Thru™ cell kit is ideal for rapid liquid methods when high throughput of analysis is needed.

HACH®
Be Right™

Specifications*

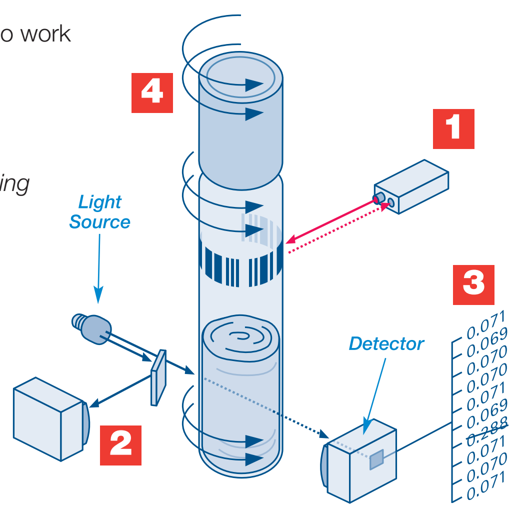
Operating Mode	Transmittance (%), Absorbance, and Concentration
Source Lamp	Tungsten
Pre-Installed Programs	More than 240
Available User Programs	50
Data Storage	500 points
Export Capability	.csv (comma-separated values) file format
Wavelength Range	340 to 900 nm
Wavelength Accuracy	±1.5 nm
Wavelength Resolution	1 nm
Spectral Bandwidth	5 nm
Wavelength Calibration	Internal, automatic at power-on, visual feedback
Wavelength Selection	Automatic: based on selected program Automatic: based on barcode printed on TNTplus™ reagent vials Manual: in all modes except stored programs
Enclosure Rating	IP 41
Operating Temperature	10 to 40°C (50 to 104°F)
Operating Humidity	80% relative humidity, non-condensing, maximum
Storage Requirements	Temperature: -25 to 60°C (-13 to 140°F) Humidity: 80% relative humidity, non-condensing, maximum
Power Requirements	Line: 100 to 240 V; 47/63 Hz; automatic changeover Battery: Lithium-Ion 11V/4400mAh
Interface	USB 1.1 (10 ft. (3 m) cable, maximum)
Languages	English, French, German, Italian, Spanish, Portuguese, Chinese, Japanese, and Korean (please contact your Hach representative for availability of additional languages)
Connections	1 x USB type B (PC) 1 x USB type A (USB storage device, printer, keyboard)
Sample Cell Compatibility	1-in. square; 1-in. round; 1 cm square; 1x5 cm; 13 mm round; 16 mm round; Multipath 1-in./1 cm; Pour-Thru™ with 1-in./1 cm path lengths
Accessories	Included: 1-in. square matched glass sample cells; Cell adapters for 1-in. round/ AccuVac cells, 1x1 cm cells, and multi-path 1-in./1 cm cells; Universal power supply, 100 to 240V, 47/63Hz, with plug adapters for EU, GB, US, China; Protective cover for storing adapters; Dust cover Optional: Hach Pour-Thru cell; External USB keyboard; Rechargeable lithium-ion battery; Carrying Case; DataTrans™ Software
Dimensions	220 x 137 x 332 mm (8.7 x 5.4 x 13.1 in.) width, height, depth
Weight	Without battery: 4.06 kg (8.95 lbs.) With battery: 4.38 kg (9.65 lbs.)

**Subject to change without notice.*

Principle of Operation

Hach's TNTplus chemistriesand spectrophotometers are made to work seamlessly with each other.

- *Many of the tests are EPA compliant.*
- *Over 35 tests available including these popular EPA Approved Parameters:*
  - Ammonia
  - COD
  - Chlorine
  - Chromium
  - Iron
  - Nitrate
  - Nitrite
  - Nitrogen
  - Phosphorus
  - Sulfate



How TNTplus Works

1 Barcode Recognition
Simply drop in the vial and get results immediately with automatic method detection.

2 Reference Detector
Monitors and compensates for optical fluctuations.

3 10X Measurement and Outlier Elimination
Dirty, scratched, or flawed glassware, including fingerprints, is no longer an issue—instrument averages 10 readings and rejects outliers.

4 Self-Contained Packaging—Reagents Inside Sealed Cap
Reduces exposure to chemicals—no need to open pillows or clean glassware.

See our TNTplus video at: www.hach.com/tntplus

Available Tests

The following table lists available tests and overall ranges for the Hach DR 2800 Portable Spectrophotometer. The ranges may represent more than one available test for the instrument. Consult your Hach representative, Customer Service, the Hach Master Catalog, or the Hach web site at www.hach.com for complete details of all available tests for this instrument.

Parameter	Range	TNTplus Test
Alachlor	0.1 to 0.5 ppb, threshold	
Alkalinity, Total	25 to 400 mg/L	•
Aluminum	0.002 to 0.800 mg/L	•
Ammonia, Nitrogen	0.015 to 50.0 mg/L	•
Arsenic	0.020 to 0.200 mg/L	
Atrazine	0.5 to 3.0 ppb, threshold	
Barium	2 to 100 mg/L	
Benzotriazole	1.0 to 16.0 mg/L	
Boron	0.2 to 14.0 mg/L	
Bromine	0.05 to 4.50 mg/L	
Cadmium	.7 µg/L to 0.30 mg/L	•
Carbohydrazide	5 to 600 µg/L	
Chloramine, Mono	0.04 to 10.0 mg/L	
Chloride	0.1 to 25.0 mg/L	
Chlorine Dioxide	0.01 to 1000 mg/L	
Chlorine, Free	0.02 to 10.0 mg/L	•
Chlorine, Total	2 µg/L to 10.0 mg/L	•
Chromium, Hexavalent	0.010 to 1.00 mg/L	•
Chromium, Total	0.01 to 0.70 mg/L	•
Cobalt	0.01 to 2.00 mg/L	
Color	3 to 500 units	
COD (Chemical Oxygen Demand)	0.7 to 15,000 mg/L	•
Copper	1 µg/L to 8.0 mg/L	•
Cyanide	0.002 to 0.240 mg/L	
Cyanuric Acd	5 to 50 mg/L	
DEHA (Diethylhydroxylamine)	3 to 450 µg/L	
Dissolved Oxygen	6 µg/L to 40 mg/L	
Erythorbic Acid (Isoascorbic acid)	13 to 1500 µg/L	
Fluoride	0.02 to 2.00 mg/L	
Formaldehyde	3 to 500 µg/L	
Hardness, Total (Calcium and Magnesium as $CaCO_3$)	4 µg/L to 4.00 mg/L	
Hydrazine	4 to 600 µg/L	
Hydroquinone	9 to 1000 µg/L	
Iodine	0.07 to 7.00 mg/L	
Iron, Ferrous	0.02 to 3.00 mg/L	
Iron, Total	0.009 to 6.0 mg/L	•

Parameter	Range	TNTplus Test
Lead	3 µg/L to 2.0 mg/L	•
Manganese	0.006 to 20.0 mg/L	
Mercury	0.1 to 2.5 µg/L	
Methylethylketoxime (MEKO)	15 to 1000 µg/L	
Molybdenum, Molybdate	0.02 to 40.0 mg/L	
Nickel	0.006 to 6.0 mg/L	•
Nitrate, Nitrogen	0.01 to 35 mg/L	•
Nitrite, Nitrogen	0.002 to 250 mg/L	•
Nitrogen, Simplified Total Kjeldahl	0 to 16 mg/L	•
Nitrogen, Total	0.5 to 150 mg/L	•
Nitrogen, Total Inorganic	0.2 to 25.0 mg/L	
Nitrogen, Total Kjeldahl	1 to 150 mg/L	
Ozone	0.01 to 1.50 mg/L	
PCB (Polychlorinated Biphenyls)	1 to 50 ppm, threshold	
Phenols	0.002 to 0.200 mg/L	
Phosphonates	0.02 to 125.0 mg/L	
Phosphorus, Acid Hydrolyzable	0.06 to 100.0 mg/L	
Phosphorus, Reactive (Orthophosphate)	19 µg/L to 100.0 mg/L	•
Phosphorus, Total	0.06 to 100.0 mg/L	•
Potassium	0.1 to 7.0 mg/L	
Quaternary Ammonium Compounds	0.2 to 5.0 mg/L	
Selenium	0.01 to 1.00 mg/L	
Silica	3 µg/L to 100 mg/L	
Silver	0.005 to 0.700 mg/L	
Sulfate	2 to 900 mg/L	•
Sulfide	5 to 800 µg/L	
Surfactants, Anionic	0.002 to 0.275 mg/L	
Suspended Solids	5 to 750 mg/L	
Tannin and Lignin	0.1 to 9.0 mg/L	
TOC (Total Organic Carbon)	0.3 to 700 mg/L	
Tolyltriazole	1.0 to 20.0 mg/L	
Toxicity	0 to 100% Inhibition	
TTHM (Trihalomethanes, Total)	10 to 600 µg/L	
TPH (Total Petroleum Hydrocarbons)	2 to 200 ppm, threshold	
Volatile Acids	27 to 2800 mg/L	•
Zinc	0.01 to 3.00 mg/L	

Ordering Information

DR2800-01B1	DR 2800 Portable Spectrophotometer; includes printed instrument manual, procedure manual on CD-ROM, universal power supply with exchangeable plug adapters for EU, GB, US, and China, dust cover, and 1-in. square matched glass sample cells. Includes a Lithium-ion Battery Pack

Replacement Parts

LZV610	Power Supply; 100 to 240V, 47 to 63 Hz, international (exchangeable plug adapters for EU, GB, US, and China)
LZV583	Adapter A; 1 cm square cells
LZV585	Adapter B; multi-path cell, 1-in./1 cm, or Pour-Thru cell
LZV584	Adapter C; 1-in. round cells
LZV565	Replacement Bulb; 6V, 10W
LZV642	Protective Cover for storing adapters
LZV646	Light Shield
HYH019	Dust Cover

Optional Accessories

5940400	Pour-Thru Cell Kit; includes 1-in. Pour-Thru cell, holder, funnel, and tubing
LZV537	Certified Test Filter Set
2960100	Citizen PD-24 Printer Package
LZV582	USB Keyboard
LZV566	USB Hand-held Barcode Scanner
LZV551	Battery Pack (lithium-ion 11 V/4400 mAh)
5839700	DR 2800 Carrying Case
LZY274	DataTrans™ Software

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United States: 800-227-4224 tel 970-669-2932 fax orders@hach.com
Outside United States: 970-669-3050 tel 970-461-3939 fax int@hach.com
hach.com

LIT2489 Rev 4
L12 Printed in U.S.A.

Remediation, Assessment & Industrial Testing

RaPID Assay®

Pentachlorophenol (PCP) RaPID Assay

Features

- rapid field testing procedure for analysis of soil and water samples
- quantitative data results with excellent analytical precision
- test up to 50 samples at one time
- results in approximately 60 minutes
- training recommended
- magnetic particle immunoassay
- EPA SW-846 Method #4010

MODERNWATER

Test Result Type

- Quantitative, semi-quantitative or qualitative.

Samples per Kit

- Two kit sizes available:
  - 30 Test Kit (tests up to 20+ samples)
  - 100 Test Kit (tests up to 80+ samples)

Assay Range

- Soil:
  0.10 to 10.0 ppm
  as pentachlorophenol
- Water:
  0.06 to 10.0 ppb
  as pentachlorophenol
- Wood applications are also available.
- Range can be extended via additional dilutions.

Sample Preparation

- Soil samples require prior extraction using the Sample Extraction Kit (sold separately).
- The Sample Extraction Kit provides materials for 12 soil sample extractions with alkaline methanol.

Sampling Time

- Soil extraction time is typically 2 minutes per sample plus assay run time of approximately 60 minutes.

Remediation, Assessment & Industrial Testing

RaPID Assay®

Modern Water Inc
15 Read's Way, Suite 100
New Castle, DE 19720

Direct: 302-669-6900
Toll Free: 855-637-6426
Fax: 877-766-3944
web: www.modernwater.com

Basic Test Procedures

- Add prepared sample, enzyme conjugate, and antibody coupled magnetic particles. Vortex.
- Incubate for 30 minutes.
- Separate using the RaPID Magnetic Separator, decant & wash.
- Add solution and incubate 20 minutes.
- Stop the reaction and read color at 450 nm.
- Quantitative results and QC parameters are calculated and printed automatically using the RPA-I spectrophotometer.

Specificity

The PCP RaPID Assay immunoassay test does not differentiate between PCP and other organochlorines. The table below shows compounds at the limit of quantitation (LOQ) - an approximate concentration required to yield a positive result at the lowest standard. The IC50 is the concentration required to inhibit one-half of the color produced by the negative control. It is also used to calculate cross-reactivity values to similar compounds.

PCP in Soil (ppm)

Contaminant	LOQ	IC50
Pentachlorophenol	0.1	2.2
2,3,5,6-Tetrachlorophenol	0.19	4.1
2,3,4,6-Tetrachlorophenol	0.66	14.6
2,3,5-Trichlorophenol	5.4	119
2,3,6-Trichlorophenol	2.9	62.9
Tetrachlorohydroquinone	6.7	148
2,4,6-Trichlorophenol	21.0	463
2,4,5-Trichlorophenol	26.0	574
2,3,4-Trichlorophoenol	78.6	1730
2,5-Dichlorophenol	356	7830
2,6-Dichlorophenol	272	5990
2,3-Dichlorophenol	>455	>10000
2,4-Dichlorophenol	>455	>10000
3,5-Dichlorophenol	>455	>10000
Hexachlorobenzene	>455	>10000
Hexachlorocyclohexane	>455	>10000

Test Kit Components

- Antibody coated magnetic particles for analysis of 30 or 100 test tubes
- Diluent zero, wash, enzyme conjugate, color development and stop reagents
- Standards for 0.1, 2, and 10 ppb as PCP
- Kit control at 1.0 ppb PCP
- Disposable test tubes
- Test kit instructions

Storage & Precautions

- Shelf life is typically one year from date of manufacture, with specific kit expiration date information provided on product packaging.
- Reagents must be stored at 39° to 46°F (4° to 8°C) when not in use.
- Storage at ambient temperature 64° to 81°F (18° to 27°C) is acceptable for day of use.
- Kits must be brought to 64° to 81°F (18° to 27°C) before use.
- Do not expose color solution to direct sunlight.
- Portable spectrophotometer battery should be charged prior to use.

Required Test Materials	*Part #*
° PCP 30 tube test kit	A00110
° PCP 100 tube test kit	A00111
° SDI Sample Extraction Kit	A00128EA
° PCP Sample Diluent (as needed)	A00113
° Universal Range Extension Kit (as needed to extend range)	A00235

Required Test Equipment	
° RaPID Assay Accessory Kit	6050100 purchase
which contains:	6997010 rental
RPA-I RaPID Analyzer	A00003
Magnetic Separation Rack	A00004
Repeator Pipet	A00008
Adjustable Volume Pipet	A00176
Vortex Mixer	A00014
Portable Balance	A00131
Digital Timer	A00015
° Repeator Pipet Tips	A00009
° Adjustable Pipet Tips	A00013

Other Recommended Materials

- Latex gloves
- Liquid and solid waste containers
- Calculator
- Absorbant paper for blotting
- Marking pen

Appendix F
Example Data Validation Checklists

Stage 2A Data Validation Checklist for General Chemistry Sample Analysis

Site: **Case No:** **Laboratory:**
Project: **Sample Matrix:** **Analyses:**
Sample Date(s): **Analysis Date(s):**
Data Validator: **Validation Date(s):**

1. Holding Times

Analyte	Laboratory	Matrix	Method	Holding Times	Collection Date(s)	Analysis Date(s)	Holding Time Met (Y/N)	Affected Data Flagged (Y/N)

Were any data flagged because of holding time? Y ☐ N ☐
Were any data flagged because of preservation problems? Y ☐ N ☐

Describe Any Actions Taken:

Comments:

2. Blanks

Were Method Blanks (MBs) analyzed at the frequency of 1 per analytical batch? Y ☐ N ☐
Were MBs within the control window? Y ☐ N ☐
Were any data flagged because of blank problems? Y ☐ N ☐

Describe Any Actions Taken:

Comments:

3. Laboratory Control Samples

Were Laboratory Control Samples (LCS) analyzed at the frequency of 1 per batch? Y ☐ N ☐
Were LCS results within the control window? Y ☐ N ☐
Were any data flagged because of LCS problems? Y ☐ N ☐

Describe Any Actions Taken:

Comments:

4. Duplicate Sample Results

Were Laboratory Duplicate Samples (LDS) analyzed at the frequency of 1 per batch? Y ☐ N ☐
Were LDS results within the control window? Y ☐ N ☐
Were any data flagged because of LDS problems? Y ☐ N ☐

Describe Any Actions Taken:

Comments:

5. Matrix Spike Sample Results

Were Laboratory Matrix Spike Samples (LMS) analyzed at the frequency of 1 per batch? Y ☐ N ☐
Were LMS results within the control window? Y ☐ N ☐
Were any data flagged because of LMS problems? Y ☐ N ☐

Describe Any Actions Taken:

Comments:

6. Field Blanks

Were field blanks submitted as specified in the Sampling Analysis Plan (SAP)?	Y		N		N/A	
Were field blanks within the control window?	Y		N		N/A	
Were any data qualified because of field blank problems?	Y		N		N/A	

Describe Any Actions Taken:

Comments:

7. Field Duplicates

Were field duplicates submitted as specified in the Sampling Analysis Plan (SAP)?	Y		N		N/A	
Were results for field duplicates within the control window?	Y		N		N/A	
Were any data qualified because of field duplicate problems?	Y		N		N/A	

Describe Any Actions Taken:

Comments:

8. Overall Assessment

Are there analytical limitations of the data that users should be aware of?	Y		N	

If so, explain:

Comments:

9. Authorization of Data Validation

Data Validator **Name:**		**Reviewed by:**
Signature:	____________________	____________________
Date:	____________________	____________________

Stage 2A Data Validation Checklist for Metals Sample Analysis

Site: **Case No:** **Laboratory:**
Project: **Sample Matrix:** **Analyses:**
Sample Date(s): **Analysis Date(s):**
Data Validator: **Validation Date(s):**

1. Holding Times

Analyte	Laboratory	Matrix	Method	Holding Times	Collection Date(s):	Analysis Date(s)	Holding Time Met (Y/N)	Affected Data Flagged (Y/N)

Were any data flagged because of holding time? Y ☐ N ☐
Were any data flagged because of preservation problems? Y ☐ N ☐

Describe Any Actions Taken:

Comments:

2. Blanks

Were Method Blanks (MBs) analyzed at the frequency of 1 per analytical batch? Y ☐ N ☐
Were MBs within the control window? Y ☐ N ☐
Were any data flagged because of blank problems? Y ☐ N ☐

Describe Any Actions Taken:

Comments:

3. Laboratory Control Samples

Were Laboratory Control Samples (LCS) analyzed at the frequency of 1 per batch? Y ☐ N ☐
Were LCS results within the control window? Y ☐ N ☐
Were any data flagged because of LCS problems? Y ☐ N ☐

Describe Any Actions Taken:

Comments:

4. Duplicate Sample Results

Were Laboratory Duplicate Samples (LDS) analyzed at the frequency of 1 per batch? Y ☐ N ☐
Were LDS results within the control window? Y ☐ N ☐
Were any data flagged because of LDS problems? Y ☐ N ☐

Describe Any Actions Taken:

Comments:

5. Matrix Spike Sample Results

Were Laboratory Matrix Spike Samples (LMS) analyzed at the frequency of 1 per batch? Y ☐ N ☐
Were LMS results within the control window? Y ☐ N ☐
Were any data flagged because of LMS problems? Y ☐ N ☐

Describe Any Actions Taken:

Comments:

6. Field Blanks

Were field blanks submitted as specified in the Sampling Analysis Plan (SAP)?	Y	☐	N	☐	N/A	☐
Were field blanks within the control window?	Y	☐	N	☐	N/A	☐
Were any data qualified because of field blank problems?	Y	☐	N	☐	N/A	☐

Describe Any Actions Taken:

Comments:

7. Field Duplicates

Were field duplicates submitted as specified in the Sampling Analysis Plan (SAP)?	Y	☐	N	☐	N/A	☐
Were results for field duplicates within the control window?	Y	☐	N	☐	N/A	☐
Were any data qualified because of field duplicate problems?	Y	☐	N	☐	N/A	☐

Describe Any Actions Taken:

Comments:

8. Overall Assessment

Are there analytical limitations of the data that users should be aware of? Y ☐ N ☐

If so, explain:

Comments:

9. Authorization of Data Validation

Data Validator		
Name:		**Reviewed by:**
Signature:	______________________________	______________________________
Date:	______________________________	______________________________

Data Validation Checklist for Organics (GC-MS) Sample Analysis

Site: **Case No:** **Laboratory:**

Project: **Sample Matrix:** **Analyses:**

Sample Date(s): **Analysis Date(s):**

Data Validator: **Validation Date(s):**

1. Holding Times

Analytes	Laboratory	Matrix	Method	Holding Times	Collection Date	Batch	Prep Date	Analysis Date(s)	Holding Time Met (Y/N)	Affected Data Flagged (Y/N)

*Reference for Holding Times –

Were any data flagged because of holding time? Y ☐ N ☐

Were any data flagged because of preservation problems? Y ☐ N ☐

Describe Any Actions Taken:

Comments:

2. Instrument Calibration

Was the Tune analysis information performed? Y ☐ N ☐

Was the Ion Abundance Criteria met for DFTPP? Y ☐ N ☐

Was Instrument successfully calibrated at the correct frequency? Y ☐ N ☐

Was Instrument calibrated with appropriate standards and blanks? Y ☐ N ☐

Were Initial Calibration Verification (ICV) and Continuing Calibration Verification (CCV) samples analyzed? Y ☐ N ☐

Were ICV and CCV results within the control window? Y ☐ N ☐

Were any data flagged because of calibration problems? Y ☐ N ☐

Describe Any Actions Taken:

Comments:

3. Blanks

Was a Method Blank (MB) analyzed at the frequency of 1 per analytical batch? Y ☐ N ☐

Was the Method Blank within the control window? Y ☐ N ☐

Were any data flagged because of blank problems? Y ☐ N ☐

Describe Any Actions Taken:

Comments:

4. Surrogates

Were surrogates present in all extracted samples (including QC)? Y ☐ N ☐

Were surrogate recoveries within the control window? Y ☐ N ☐

Were any data flagged because of surrogate problems? Y ☐ N ☐

Describe Any Actions Take:

Comments:

5. Laboratory Control Samples

Were Laboratory Control Samples (LCS) analyzed at the frequency of 1 per batch?	Y	☐	N	☐
What was the source of the LCS?				
Were LCS results within the control window?	Y	☐	N	☐
Were any data flagged because of LCS problems?	Y	☐	N	☐

Describe Any Actions Taken:

Comments:

6. Duplicate Sample Results

Were Laboratory Duplicate Samples (LDS) analyzed at the frequency of 1 per batch?	Y	☐	N	☐
Were LDS results within the control window?	Y	☐	N	☐
Were any data flagged because of LDS problems?	Y	☐	N	☐

Describe Any Actions Taken:

Comments:

7. Matrix Spike Sample Results

Were Laboratory Matrix Spike Samples (LMS) analyzed at the frequency of 1 per batch?	Y	☐	N	☐
Were LMS % Recovery (%R) results within the control window?	Y	☐	N	☐
Were any data flagged because of LMS problems?	Y	☐	N	☐

Describe Any Actions Taken:

Comments:

8. Internal Standards

Were internal standards added to each sample in the analytical batch?	Y	☐	N	☐
Were the area responses within the control window?	Y	☐	N	☐
Were the Retention Time (RT) shifts within the control window?	Y	☐	N	☐
Were any data flagged because of internal standard problems?	Y	☐	N	☐

Describe Any Actions Taken:

Comments:

9. Mass Spectra

Do all positively identified target analyte mass spectra match corresponding analyte in the opening CCV or the mid-point standard of the initial calibration?	Y	☐	N	☐
Are the relative intensities of these ions within the control window?	Y	☐	N	☐
Are the RT for positively identified target analytes within the control window?	Y	☐	N	☐
Were any data flagged because of Mass Spectra problems?	Y	☐	N	☐

Describe Any Actions Taken:

Comments:

10. Field Blanks

Were field blanks submitted as specified in the Sampling Analysis Plan (SAP)?	Y	☐	N	☐		
Were field blanks within the control window?	Y	☐	N	☐	N/A	☐
Were any data qualified because of field blank problems?	Y	☐	N	☐	N/A	☐

Describe Any Actions Taken:

Comments:

11. Field Duplicates

Were field duplicates submitted as specified in the Sampling Analysis Plan (SAP)?	Y	☐	N	☐		
Were the field duplicates within the control window?	Y	☐	N	☐	N/A	☐
Were any data qualified because of field duplicate problems?	Y	☐	N	☐	N/A	☐

Describe Any Actions Taken:

Comments:

12. Overall Assessment

Are there analytical limitations of the data that users should be aware of? Y ☐ N ☐

If so, explain:

Comments:

13. Authorization of Data Validation

Data Validator

Name: **Reviewed by**:

Signature: ______________________ ______________________________

Date: ______________________ ______________________________

Level A/B Screening Checklist

1. General Information

Site:
Project:
Client:
Sample Matrix:

2. Screening Result

Data are:
1. Unusable ______
2. Level A ______
3. Level B ______

I. **Level A**

Criteria – The following must be fully documented.	**Yes/No**	**Comments**
1. Sampling date		
2. Sampling team or leader		
3. Physical description of sampling location		
4. Sample depth (soils)		
5. Sample collection technique		
6. Field preparation technique		
7. Sample preservation technique		
8. Sample shipping records		

II. **Level B**

Criteria – The following must be fully documented.	**Yes/No**	**Comments**
1. Field instrumentation methods and standardization complete		
2. Sample container preparation		
3. Collection of field replicates (1/20 minimum)		
4. Proper and decontaminated sampling equipment		
6. Field custody documentation		
7. Shipping custody documentation		
8. Traceable sample designation number		
9. Field notebook(s), custody records in secure repository		
10. Completed field forms		