

December 23, 2024

Mr. David Hunter
Montana City Properties, Inc.
P.O. Box 5804
Helena, Montana 59601

RE: Remedial Investigation Work Plan for the Petroleum Release at Montana City Store, 1 Jackson Creek Road, Montana City, MT 59634; Facility ID 22-01822, Releases 206 and 2709

Mr. Hunter:

Tetra Tech has prepared this Remedial Investigation Work Plan for the subject property at 1 Jackson Creek Road located in Montana City, Montana (**Figure 1, Attachment A**). This Work Plan was prepared in response to the Montana Department of Environmental Quality (DEQ) letter dated October 15, 2024, and discussed with DEQ during our meeting on November 7, 2024. Specifically, this Work Plan includes the following elements as directed by the DEQ:

- Evaluation of an existing site well for vertical plume delineation
- Gathering current water quality data
- Gathering current aqueous intrinsic biodegradation data
- Obtaining soil analytic data from the vadose zone near the historic tank basin
- Installation of an injection test well
- Completion of a clean water injection pilot test to identify the viability of chemical injections at the Site to address persistent dissolved phase petroleum contamination.

Also included are data evaluation, preparation of a Remedial Investigation Report, and preparation of an updated Release Closure Plan.

This Work Plan is organized to present the following information:

1. Background
2. Objectives
3. Scope of Work
4. Schedule
5. Estimated Cost

The referenced figures in this Work Plan are included in **Attachment A**; referenced tables are in **Attachment B**; and a breakdown of costs and subcontractor quotes received for this work are included as **Attachment C**.

BACKGROUND

The Montana City Store is a convenience store, retail fuel station located at 1 Jackson Creek Road in Montana City, approximately 5 miles southeast of Helena, Montana (**Figure 1, Attachment A**). The property has been owned by HHR, LLP with the mailing address of 1 Jackson Creek Road, PMB 2249, Montana City 59634, since 2007.

Four underground storage tanks (USTs) were installed in the northeast corner of the Site in 1978 and then removed in August 1988 during facility upgrades. Three current (active) USTs were installed during July 1988, along with the three current dispenser islands. On February 22, 1990, two leaks were identified in the newly installed UST system and assigned Release #206. The first leak was a “dripping type leak in the super-unleaded dispenser” and the second leak was a flow type leak at the top of the super-unleaded tank. A soil vapor extraction (SVE) system was installed on February 27, 1990, which was coupled to two wells in the current tank basin to abate impacted soil associated with Release #206. The electrical blower on this system was replaced by passive roof vents in May 1990. Passive roof vents are presumed to have operated through the present as there is no further information in the record.

In 1991, benzene was reported in the supply well for the Montana City Store, which was then removed from service but not abandoned. A soil gas survey was conducted in August 1991 by SRM, Inc. to determine the source of petroleum hydrocarbon impacts in the supply well. Results indicated impacts to the supply well were not caused by hydrocarbons from Release # 206, but rather were linked to hydrocarbon concentrations found in the area of the original UST tank basin closed in 1988. This second source was assigned Release #2709. Later that same year, two soil borings within and adjacent to the former UST basin of Release #2709 were performed. One of the borings was converted into a vapor extraction well to begin remediation of the impacts associated with the former underground storage tanks. Based on limited reference to this vapor extraction well, it is believed to have operated nearly continuously through 1997. The record is unclear whether this vapor extraction well was incorporated into a designed system installed in 1997, abandoned, or simply discontinued use of. The designed system was installed in the northeast portion of the Site and began operation in January 1998 to abate impacts associated with Release #2709. This SVE system operated through August 1998 when recoveries had dropped to near zero ppm. The system was reportedly off in February 1999.

In 1993, four (4) monitoring wells (MC-2B, -3B, -4B and -5B) were installed at the Site. Groundwater monitoring detected light non-aqueous phase liquid (LNAPL) in one of the wells and elevated levels of benzene in groundwater samples from two of the other three wells. Supplemental phases of remedial investigation were conducted to investigate the extent and magnitude of subsurface impacts from the two releases. Five wells (MW-6C, -7C, -9C, -10C and -11C) were installed in 1994. In August 1996, the DEQ issued a “No Further Corrective Action” letter for Release #206. However, in March 2000, the DEQ reopened Release #206 and requested a work plan for further investigation and remediation.

In response to requested additional investigation of Release #206, wells MW-12 and MW-13 were installed during a remedial investigation conducted in 2001 and wells MW-14, MW-15, and MW-16 were installed during a remedial investigation conducted in 2006. Wells MW-5 and MW-16 appear to have been destroyed during construction of a roundabout at the intersection of Jackson Creek Road and Highway 282 during 2007-2008.

In 2007, HHR, LLP, commonly referred to as Montana City Properties (MTCP), purchased the Montana City Store property. In 2011, DEQ requested MTCP conduct a groundwater monitoring event. Tetra Tech, Inc. was retained by MTCP to perform the monitoring event. Prior to sampling, the existing wells were rehabilitated in an effort to remove sediment and debris from the wells. In January 2013, Tetra Tech

completed a remedial investigation at the Site that included installation of four monitoring wells (MW-17, -18, -19, and -20). This investigation was followed by a Remedial Alternatives Analysis in 2014, which recommended conducting an SVE and air sparge (AS) pilot test. Four SVE wells and one AS well were installed specifically for the pilot test. Results of the testing indicated a radius of influence of less than 10 feet due to low permeability of the affected soil. As part of this event, the SVE system for Release #2709 (former tank basin) was temporarily reactivated, which exhibited 0.22 inches of H₂O vacuum at approximately 22 feet distance; 11 parts per million (ppm) photoionization detector (PID) measurement, and 13 ppm C₂ to C₁₀ hydrocarbon laboratory sample result after one hour of run time.

In July 2016, a new supply well was installed at the southeast corner of the Jackson Creek Saloon property north of the Site. This well contained gasoline range petroleum concentrations and was subsequently abandoned. Four additional monitoring wells (MW-21 through MW-24) were installed from 2016 to 2023, with corresponding groundwater monitoring events.

Continuing investigations indicated that constituents of concern consist of gasoline range fuels associated with former USTs, historic plumbing leaks from current USTs, and possible small quantity customer surface overfills. The groundwater potentiometric flow direction is consistently to the northeast; however, monitoring wells less than 200 feet to the east, northeast, and north have consistently been below detection limits for volatile petroleum hydrocarbon (VPH) constituents; or were dry in the case of well MW-24. The highest groundwater concentrations are reported in well MW-23, which was installed immediately adjacent to or within the pre-1988 UST basin (Release #2709).

Site geology consists of a stiff, tan to light grey/green, weathered volcanic ash having clay-like texture and containing thin layers of bentonite to varying depths up to 75 feet. Depth to water in site monitoring wells ranges from 19 feet to greater than 65 feet below ground surface and may fluctuate greatly over short distances (e.g., 10 feet), depending on location.

A receptor survey was completed in 2019. Twelve water supply wells were identified within a 1,000-foot radius of the groundwater plume. Wells within 500 feet of the Site were sampled for volatile organic compounds. All analytes were below the method detection limit at all locations.

OBJECTIVES

Objectives for this Work Plan are as follows:

- Evaluate the former Site Supply Well for use in vertical plume delineation.
- Document spatial distribution and magnitude of dissolved phase constituents.
- Evaluate natural biodegradation and matrix demand for potential remedial additive prescription.
- Obtain soil analytic data from the vadose zone near the historic tank basin.
- Evaluate viability of chemical injection at the Site to address persistent dissolved phase impacts in groundwater.

SCOPE OF WORK

Achievement of the objectives above will be pursued through the scope of work described in this section as defined by the six tasks listed below.

Task 1: Work Plan

The first task is development of this Remedial Investigation Work Plan to present the scope, schedule and estimated costs associated with the proposed investigation and pilot testing activities. This document is required to be submitted to the DEQ and the Petroleum Tank Release Compensation Board (PTRCB) for approval to remain eligible for reimbursement of costs.

Task 2: Project Management

This task includes all labor associated with purchasing and/or renting supplies, contractor coordination, field coordination, invoicing, and client and regulatory communications.

Additionally, to comply with Occupation Safety and Health Administration Code of Federal Regulations (CFR) 29 1910.120, Tetra Tech will update a site-specific Health and Safety Plan (HASP) for the work and environmental conditions expected to be encountered. The objective of the HASP is to disclose potential chemical and physical hazards that may be encountered at a site, identify job hazards associated with field activities, describe safe work practices, identify personal protective equipment, decontamination procedures, project contacts, emergency medical procedures, and the location of the nearest medical facility.

Task 3: Former Supply Well Evaluation

In 2022, Tetra Tech personnel located the Site's former private supply well that was reported to have been abandoned. During pump removal, Tetra Tech observed that the PVC inner casing began at a depth of approximately 80 feet (ft) below ground surface. Also, during pump removal, 160 ft of PVC casing was extracted with the pump, and the pump was found to have been set at 240 ft below ground surface. The original drillers log for well installation indicates 6-inch steel was installed to the total depth of 310 ft with an open bottom and no mention of any PVC inner casing. The depth to the inner PVC casing suggests the bottom of the steel casing is likely 80 to 100 ft below ground surface. Tetra Tech will use a downhole camera to visually inspect for the bottom of the steel casing and any other components of well construction. If the steel casing terminates between 80 to 100 ft below ground surface, and is an open hole for some depth thereafter, Tetra Tech anticipates this well will be a viable sampling point to evaluate the vertical extent of the plume to the cased depth of the well.

Task 4: Groundwater Monitoring

Tetra Tech will complete one groundwater monitoring event after Task 3 is completed. If results of Task 3 indicate that the former supply well can be used to evaluate the vertical extent of the plume, Tetra Tech will include the former supply well in the monitoring event. The monitoring event will include static water level and/or free product thickness measurements (if applicable) in all 19 site monitoring wells, followed by groundwater sample collection from 11 monitoring wells. All samples will be collected using low flow sampling protocols (i.e., field parameter stabilization of temperature, pH, dissolved oxygen, conductivity, oxidation reduction potential, and turbidity with flow rates between 0.1 – 0.5 liters per minute). Select locations will be analyzed for VPH, extractable petroleum hydrocarbons (EPH), and intrinsic biodegradation indicators (IBI's), including nitrate, nitrate+nitrite, methane, biological oxygen demand (BOD), sulfate, manganese, and ferrous iron. Sample collection and analysis will be optimized to fill gaps in the site database while cost-effectively limiting the number of samples and laboratory tests. **Figure 3**

(**Attachment A**) and **Table 1 (Attachment 2)** provide a summary of location and sample prescription. **Table 2 (Attachment 2)** provides a summary of analytic methods and holding times for groundwater samples.

Groundwater samples will be placed in an ice-filled cooler upon collection and hand delivered to Energy Laboratories in Helena, Montana for prescribed analyses under appropriate chain-of-custody forms and seals.

Task 5: Clean Water Injection

Review of remedial alternatives by both Tetra Tech in its 2014 Remedial Alternatives Analysis Report and West Central Environmental Consultants in its 2024 Remedial Alternatives Analysis Report suggest that *in-situ* Chemical Oxidation (ISCO) or use of Oxygen Release Compounds (ORC) or equivalent may have the greatest potential to reduce constituent concentrations. Both remedial approaches require a chemical or mixture injection into the saturated and/or vadose zone. To better evaluate the viability of this remedial approach, Tetra Tech proposes to install one pilot injection test well and conduct a clean water pilot injection test into that well.

The proposed injection test well is located immediately upgradient from the former tank basin in the northeast corner of the property. Specifically, it is located 15 feet northeast of MW-11 and 30 feet southeast of MW-23 (**Figure 2, Attachment A**). This location was chosen for the following reasons:

1. Location is close to source area yet expected to be in native soil.
2. Location is immediately upgradient from the current most significant source area but within impacted media for possible future chemical injection.
3. Location is within impacted media to obtain soil chemistry data useful for possible chemical injection design and/or natural attenuation evaluation.
4. Wells MW-11, MW-23, and MW-19 (15 ft, 30 ft, and 45 ft distance, respectively) can be used to monitor clean water injection and possible future chemical injection.
5. Does not disturb long term monitoring locations.
6. Easiest area to exclude public access while conducting activities.

Ideally, an injection would be completed using a direct-push boring so that the depth, at which water can flow into the subsurface, can be determined. However, previous drilling indicates that direct-push technology is not viable to achieve the target depths described below. Historic drilling by hollow stem auger and air rotary methods have provided limited core sample returns. Therefore, Tetra Tech proposes to install the soil boring and subsequent injection well using sonic drilling methods. Using this method, the soil boring can be advanced to a target depth of 35 ft using a 4-inch core barrel and no drilling fluids. This method has the highest probability of providing a relatively continuous core of adequate volume to complete field screening and laboratory analyses of the soil encountered during drilling.

Tetra Tech will provide an experienced professional to oversee boring installation and well completion. This individual will be responsible for site safety, log the soil core, complete field PID headspace screening at 5-foot intervals, and containerize soil of the highest PID reading for laboratory analysis of VPH, EPH, and total organic carbon. Excess soil cuttings will be containerized, and a composite sample submitted for VPH and EPH constituents to characterize the waste for disposal. **Table 3 (Attachment B)** provides a summary of analytic methods and holding times for soil samples.

The boring would then be completed using standard well construction methods as a 2-inch injection well (IW-1) screened from approximately 10 ft to 35 ft below ground surface with a flush-mount surface completion.

After approximately one week, newly installed well IW-1 will then be used to conduct a clean water injection test. This injection test will provide an indication of whether or not water can be injected into the vadose and water bearing zones, and, if successful, an estimate of what volumes could be anticipated and how large a zone of influence would be created around each injection point. A clean water injection test will require rentals of a pump, flow meter, and pressure transducers to monitor water levels. The volume of the filter pack will be calculated before the beginning of the test. Water will be obtained from the Jefferson Hills Water Use Association Community public water supply (PWSID MT0002978), which supplies domestic water to the Site. Injecting water into the system could create a mound of water; therefore, transducers would be placed in IW-1, MW-11, MW-19, and MW-23 to monitor the results of the test. Water levels will be measured, and pressure transducers programmed and installed in selected wells (**Figure 2, Attachment A**) a minimum of 12 hours prior to beginning injection to establish any baseline water level trends. Pressure transducers will continue recording periodic measurements throughout injection, and at least 12 hours after termination of injection, to evaluate delayed influences on monitored locations. Water will be injected in a step wise fashion to evaluate the ability of the water bearing and vadose zones to receive liquid. The initial flow rate will be 2 gallons per minute (gpm), with a goal of injecting for approximately one hour. If successful, the flow rate could then be increased to 4 or 5 gpm and the procedure repeated in steps until the system is unable to accept additional water without creating excessive pressures or discharging at the ground surface. If the system is unable to accept 2 gpm, the test will be terminated since the radius of influence would be deemed too small for efficient chemical injection.

Based upon our evaluation of results from Tasks 4 and 5, Tetra Tech will develop a recommendation as to whether chemical injection is a viable solution for remediation. If injection into the soils is possible and a radius of influence determined, a chemical injection program could be designed that may include use of direct push borings to shallow depths and/or other drilling methods. If the clean water injection test indicates that the vadose and water bearing zones will not accept the water at reasonable rates, then we will likely recommend that chemical injection not be conducted, and other remedies will need to be considered.

Task 6: Reporting

Tetra Tech will prepare a Remedial Investigation Report (Report RPT_RI) following completion of the field activities and receipt of laboratory analytic data. The Report will be prepared in accordance with DEQ's Draft Remedial Investigation Guidance document dated October 2017. The report will include an executive summary and the following information:

- Facility history and release background
- Appropriate annotated maps and figures depicting potentiometric flow direction and iso-concentrations (if mappable)
- Tabulated site analytic data compared to current Risk-Based Screening Levels
- Field intrinsic biodegradation indicator results
- Summary of the 2019 receptor survey
- Summary of previous soil investigations (if any)
- Summary of the current groundwater investigation and relevant findings to date
- Results from the clean water injection test along with associated technical conclusions and recommendations.

The report will include recommendations on the viability of remedial product injection and a copy of the updated release closure plan spreadsheet. An electronic copy of the report will be submitted to the DEQ.

SCHEDULE

To keep the project moving forward while also considering weather restrictions on field activities, Tetra Tech proposes the following timeline:

- Task 1 Work plan authorization by DEQ and petroleum release compensation fund obligation determination by March 14, 2025.
- Task 2 Project Management ongoing throughout the project.
- Task 3 Former Supply Well evaluation completed by April 11, 2025.
- Task 4 Groundwater monitoring completed following Task 2 (above) by April 18, 2025.
- Task 5 Injection well installation and clean water injection following Tasks 3 and 4 (above) completed by May 16, 2025.
- Task 6 Reporting submitted by July 30, 2025.

ESTIMATED COST

The estimated costs to implement this scope of work are provided in **Attachment C**.

Should you have any questions regarding this Remedial Investigation Work Plan, please contact us at (406) 437-9852.

Sincerely,



Jim Maus
Project Manager



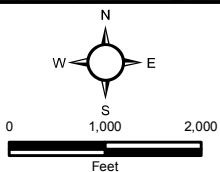
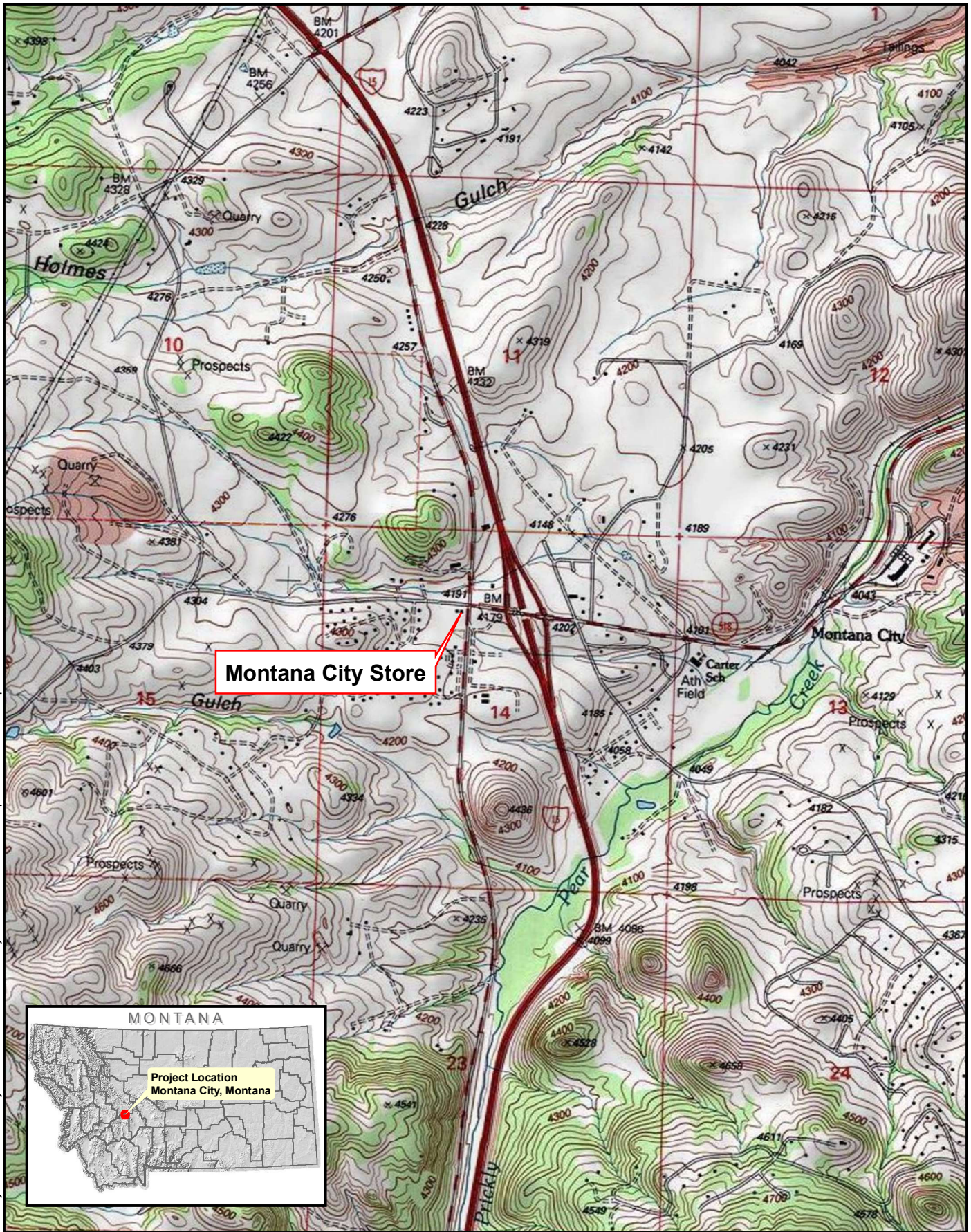
David S. Wilson, P.E., P.G.
Principal Engineer

- Attachments: A - Figure 1. Site Wells
 Figure 2. Site Features
 Figure 3. Monitoring Location Prescription
B - Table 1. 2025 Location and Analyses
 Table 2. 2025 Water Analytical Requirements
 Table 3. 2025 Soil Analytical Requirements
C - Cost Estimate & Subcontractor Quotes
D – Standard Operating Procedures (SOPs)

Cc w/ Att: Reed Miner DEQ Case Manager

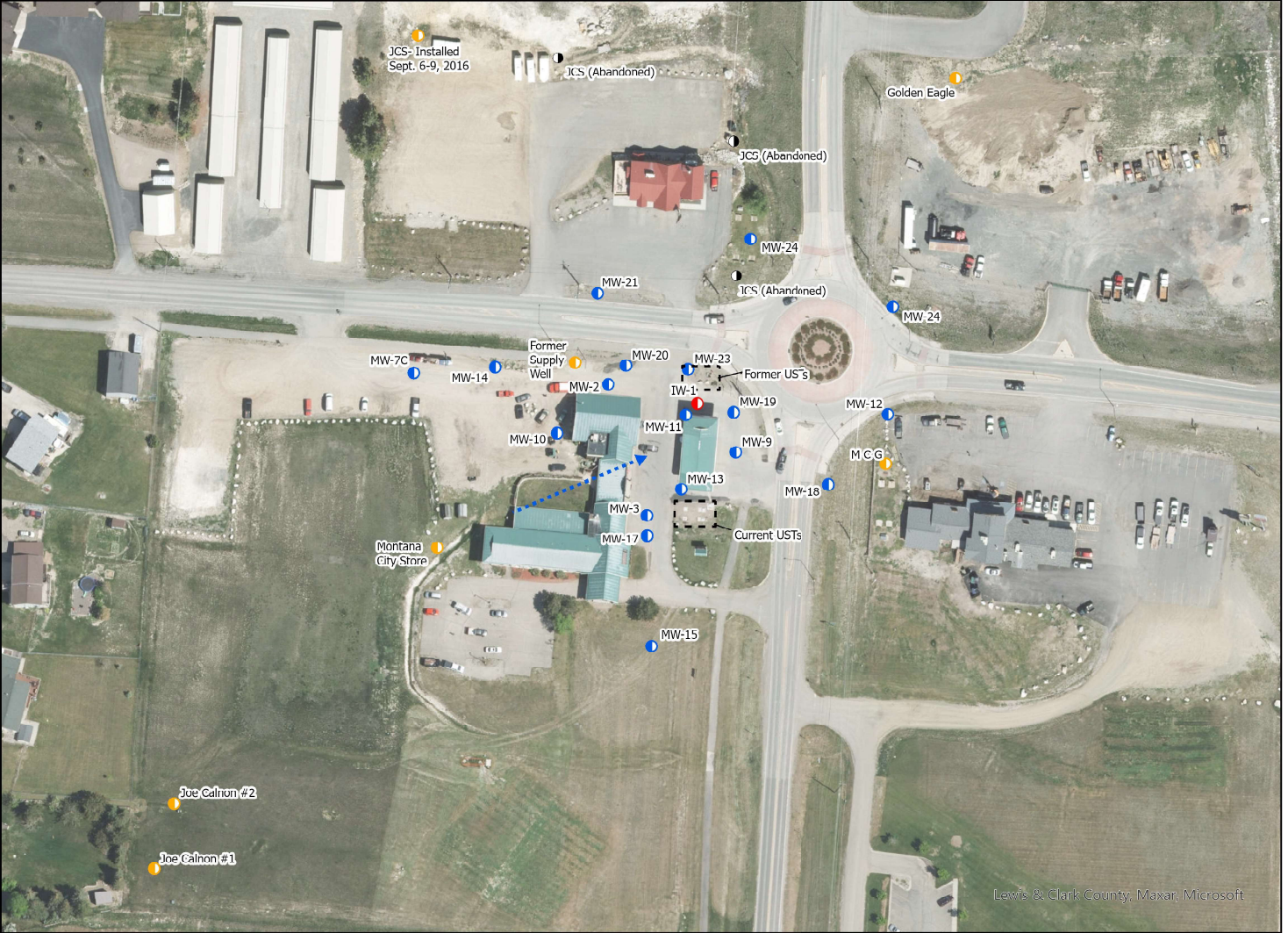
ATTACHMENT A
Figures

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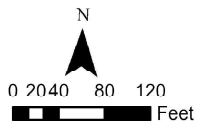
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Location Map
Montana City Store
Montana City, Montana
FIGURE 1



Lewis & Clark County, Maxar, Microsoft

Project No.: 114-560545F
12/16/2024

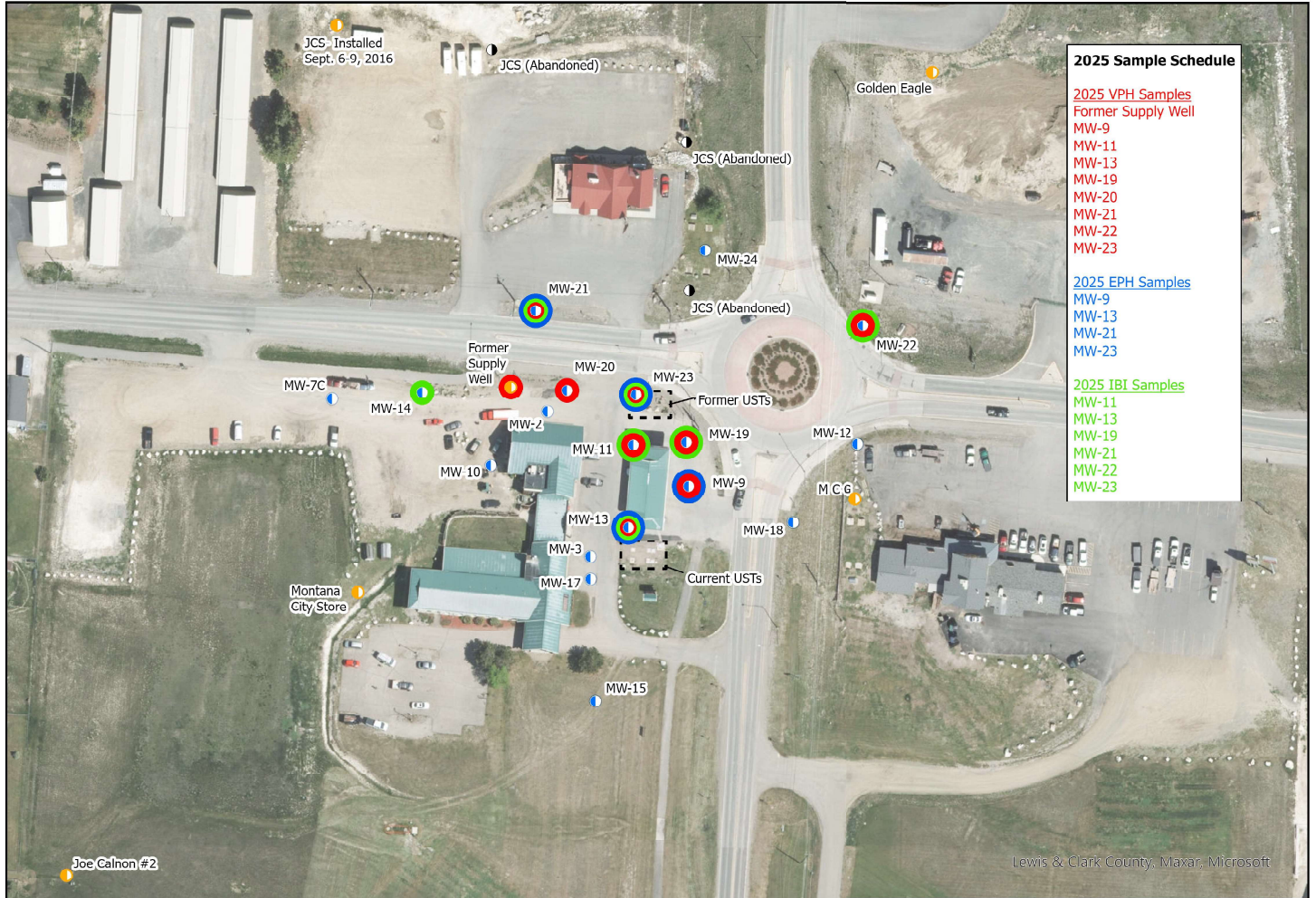


- Monitoring Wells
- Supply Wells
- Abandoned Wells
- Proposed Injection Well

--- Potentiometric
Groundwater Flow
Direction

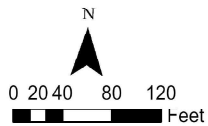
Approximate Current
and Former UST
locations

Site Features Map
Montana City Store
Figure 2



2025 Sample Schedule	
2025 VPH Samples	
Former Supply Well	
MW-9	
MW-11	
MW-13	
MW-19	
MW-20	
MW-21	
MW-22	
MW-23	
2025 EPH Samples	
MW-9	
MW-13	
MW-21	
MW-23	
2025 IBI Samples	
MW-11	
MW-13	
MW-19	
MW-21	
MW-22	
MW-23	

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12/16/2024



- Monitoring Wells
- Abandoned Wells
- Supply Wells
- 2025 IBI samples
- 2025 EPH Samples
- 2025 VPH Samples

Approximate Current and Former UST locations

**2025 Sample Schedule
Montana City Store
Figure 3**

ATTACHMENT B
Tables

Table 1. 2025 Location and Analyses

Montana City Store										
Location	Water Level ⁽¹⁾	VPH	EPH	Nitrate	Nitrate+Nitrite	Methane	BOD	Sulfate	Manganese	Iron
Former Supply Well	X	X								
MW-2	X									
MW-3	X									
MW-7	X									
MW-9	X	X	X							
MW-10	X									
MW-11	X	X		X	X	X	X	X	X	X
MW-12	X									
MW-13	X	X	X	X	X	X	X	X	X	X
MW-14	X			X	X	X	X	X	X	X
MW-15	X									
MW-17	X									
MW-18	X	X								
MW-19	X	X		X	X	X	X	X	X	X
MW-20	X	X								
MW-21	X	X	X	X	X	X	X	X	X	X
MW-22	X	X		X	X	X	X	X	X	X
MW-23	X	X	X	X	X	X	X	X	X	X
MW-24	X									
Duplicate		X	X							

⁽¹⁾ Static water level and or free product thickness as applicable.

Table 2. 2025 Water Analytical Requirements

Montana City Store			
Parameter	RL ⁽¹⁾	Method No.	Max. Holding Time
Biological			
Biochemical Oxygen Demand	2.0 mg/L	A5210B	48 Hours
Inorganics			
Methane	0.002 mg/L	SW8015M	--
Sulfate	1.0mg/L	E300.0	28 Days
Nutrients			
Nitrate	0.01 mg/L	E353.2	48 hours
Nitrate+Nitrite	0.01 mg/L	E353.2	28 Dys
Metals			
Manganese	0.001 mg/L	E200.7_8	6 Months
Iron, Ferrous	0.03 mg/L	E200.7_8	6 Months
Organics			
Volatile Petroleum Hydrocarbons			
Benzene	0.5 ug/L	MA-VPH	14 Days
Toluene	0.5 ug/L	MA-VPH	14 Days
Ethylbenzene	0.5 ug/L	MA-VPH	14 Days
Xylene, total	0.5 ug/L	MA-VPH	14 Days
o-Xylene	0.5 ug/L	MA-VPH	14 Days
m+p-Xylenes	0.5 ug/L	MA-VPH	14 Days
Naphthalene	1 ug/L	MA-VPH	14 Days
MTBE	1 ug/L	MA-VPH	14 Days
C5 to C8 Aliphatics	20 ug/L	MA-VPH	14 Days
C9 to C10 Aromatics	20 ug/L	MA-VPH	14 Days
C9 to C12 Aliphatics	20 ug/L	MA-VPH	14 Days
Total Purgeable Hydrocarbons	20 ug/L	MA-VPH	14 Days
Extractible Petroleum Hydrocarbons			
C9 to C18 Aliphatics	300 ug/L	MA-EPH	7 Days
C19 to C36 Aliphatics	300 ug/L	MA-EPH	7 Days
C11 to C22 Aromatics	300 ug/L	MA-EPH	7 Days
Total Extractable Hydrocarbons	300 ug/L	MA-EPH	7 Days

⁽¹⁾ Reporting Limit.

Table 3. 2025 Soil Analytical Requirements

Montana City Store			
Parameter	RL ⁽¹⁾	Method No.	Max. Holding Time
Biological			
Moisture	0.2 wt%	D2974	--
Organics			
Total Organic Carbon	0.05%	Leco	--
Volatile Petroleum Hydrocarbons			
Benzene	0.5 mg/Kg	MA-VPH	14 Days
Toluene	0.5 mg/Kg	MA-VPH	14 Days
Ethylbenzene	0.5 mg/Kg	MA-VPH	14 Days
Xylene, total	0.5 mg/Kg	MA-VPH	14 Days
o-Xylene	0.5 mg/Kg	MA-VPH	14 Days
m+p-Xylenes	0.5 mg/Kg	MA-VPH	14 Days
Naphthalene	1 mg/Kg	MA-VPH	14 Days
MTBE	1 mg/Kg	MA-VPH	14 Days
C5 to C8 Aliphatics	20 mg/Kg	MA-VPH	14 Days
C9 to C10 Aromatics	20 mg/Kg	MA-VPH	14 Days
C9 to C12 Aliphatics	20 mg/Kg	MA-VPH	14 Days
Total Purgeable Hydrocarbons	20 mg/Kg	MA-VPH	14 Days
Extractible Petroleum Hydrocarbons			
C9 to C18 Aliphatics	300 mg/Kg	MA-EPH	7 Days
C19 to C36 Aliphatics	300 mg/Kg	MA-EPH	7 Days
C11 to C22 Aromatics	300 mg/Kg	MA-EPH	7 Days
Total Extractable Hydrocarbons	300 mg/Kg	MA-EPH	7 Days

⁽¹⁾ Reporting Limit.

ATTACHMENT C
Cost Estimate & Subcontractor Quotes

ATTACHMENT D
Standard Operating Procedures (SOPs)

STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF CONDUCTIVITY OR SPECIFIC CONDUCTANCE (SC)

Instrument Calibration

General Considerations

- Acquire a bucket (if calibrating indoors), paper towels, nitrile or other protective material gloves, spray bottle containing distilled or de-ionized water, a calibration beaker, and buffer solutions.
- Refer to the instrument owner's manual for calibrating field parameters.
- Refer to calibration solutions for appropriate settings.
- Remove the protective cover containing probe storage solution and put in a safe place as to not spill solution.
- Inspect probe tips for damage.
- Rinse probes with spray bottle DI water, if indoors use bucket to catch rinse water, and place probe in calibration beaker. If possible keep weighted protective measuring cover on the probe during calibration.
- Ensure that all probes are submersed during calibration of each parameter as some parameters use multiple probes to obtain readings.
- Note any calibration events and off-sets in the field book associated with the meter being used.

Guidelines for Non-Temperature Compensating Meters

At the beginning each day of making measurements, determine the cell constant for the meter in the field or lab.

1. Turn on machine and check red line and zero point on meter. Adjust as necessary. If unable to reach red line, or zero point, replace batteries.
2. Plug probe into jack, and rinse probe with deionized water.
3. Measure conductivity and temperature of two KCl solution standards which best bracket the expected SC of the sample.
4. Calculate SC using the following chart to adjust conductivity measurement for temperature correction.

Temperature Correction (from table) (b)

Cell Correction Factor (from above) (c)

Adjusted Sample SC [multiply (a)(b)(c)]

7. Remove probe from sample and rinse probe with DI water. Store probe in storage solution in order to protect coating.

Maintenance

1. Store meter in its case during transport. Store probe immersed in storage solution. If storage solution is not available use deionized water or pH 7.0 buffer.
2. Check batteries before taking meter into the field and carry spare batteries and screwdriver.
3. Inspect conductivity electrodes regularly for cracks or other damage.
4. If platinum black has flaked off, a sharp end point cannot be achieved or readings are erratic. Return probe to factory so it can be replatinized.

STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF pH

Instrument Calibration

General Considerations

- Acquire a bucket (if calibrating indoors), paper towels, nitrile or other protective material gloves, spray bottle containing distilled or de-ionized water, a calibration beaker, and buffer solutions.
- Refer to the instrument owner's manual for calibrating field parameters.
- Remove the protective cover containing storage solution and put in a safe place as to not spill solution.
- Inspect probe tips for damage.
- Rinse probes with spray bottle DI water, if indoors use bucket to catch rinse water, and place probe in calibration beaker. If possible keep weighted protective measuring cover on the probe during calibration.
- Ensure that all probes are submersed during calibration of each parameter as some parameters use multiple probes to obtain readings.
- Calibrate pH meter before leaving for the field and each day in the field when pH will be measured.
- Note any calibration events and off-sets in the field book associated with the meter being used.

Calibrate using following procedure:

- Immerse electrode and temperature probe in bottle of commercial calibration solution of pH buffer 7.0. Calibrate meter to within 0.1 standard unit (s.u.). If equipment allows, always perform pH 7.0 calibration first regardless of whether using 1, 2, or 3 point calibration.
- Remove electrode and temperature probe from solution, rinse with distilled water.
- Immerse electrode and temperature probe in second pH calibration buffer having a pH of 3 units higher or lower than the first, bracketing the expected range of natural sample pH.
- The pH meter should be recalibrated during the field day, especially when air temperatures are changing by 5 or more degrees.
- Measure pH of the 7.0 buffer solutions. If the measured value differs from expected value by more than 0.1 s.u., recalibrate meter according to meter instructions.

Field Procedures

1. Rinse decontaminated glass beaker (or flow through cell) with approximately 50 milliliters of sample water three times.
2. Rinse pH electrode with deionized water.
3. Check meter using 7.0 pH buffer. Re-calibrate meter, if not within 0.1 pH units.
4. Fill beaker with sample water.
5. Immerse electrode and temperature probe in sample, agitate probes to provide thorough mixing. Continue to agitate until reading has stabilized. Read pH to nearest 0.1 s.u.
6. Record the sample pH. Note any problems such as erratic readings.
7. Rinse probe with distilled water and store according to manufacturer's directions.

Maintenance

1. Store meter in its case with electrode immersed in storage solution, if not available temporarily use distilled water or pH 7.0 buffer solution.
2. If meter is not used often, inspect bi-weekly to make sure electrode is immersed in one of the solutions described above.
3. Check batteries each time meter is used. Carry a spare battery pack and a screwdriver into the field in the pH meter case.
4. It is wise to keep an additional pH electrode available in case of probe malfunction or breakage. Usually probes are replaced as their sensitivity becomes weakened. Replace probe if stabilized readings take an unusually long time to reach, or the meter cannot be calibrated.

STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF WATER TEMPERATURE

1. Check thermometer for cracks or gaps in the solution. Do not use thermometers if either cracks or gaps are visible.
2. When conducting measurements in-situ, measure temperature of surface water at midstream by submersing the thermometer for approximately one minute or until temperature stabilizes. Temperatures should be collected from moving water, avoiding still pools which may be warmer than actual conditions.
4. When in situ temperature measurements are not possible, draw sample of at least 200 mL into a decontaminated beaker or flow through cell.
5. Place thermometer in sample. Do not allow thermometer bulb to touch sides of beaker. Allow to equilibrate (about 1 minute).
6. Record temperature to nearest 0.5 °C in field log book or on field data sheet.
7. Rinse thermometer with deionized water.
8. On a quarterly basis, check field thermometers against a NBS-certified laboratory thermometer. Agreement should be within 0.5°C.

STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF DISSOLVED OXYGEN

General Considerations

- Acquire a bucket (if calibrating indoors), paper towels, nitrile or other protective material gloves, spray bottle containing distilled or de-ionized water, a calibration beaker, and buffer solutions.
- Refer to the instrument owner's manual for calibrating field parameters and refer to calibration solutions for appropriate settings.
- Remove the protective cover containing storage solution and put in a safe place as to not spill solution.
- Inspect probe tips for damage.
- Rinse probes with spray of bottle DI water, if indoors use bucket to catch rinse water, and place probe in calibration beaker. If possible keep weighted protective measuring cover on the probe during calibration.
- Ensure that all probes are submersed during calibration of each parameter as some parameters use multiple probes to obtain readings.
- Note any calibration events and off-sets in the field book associated with the meter being used.

Field Measurements

1. Inspect dissolved oxygen (DO) meter for damage. The probe end should be examined to be sure the membrane is intact. Repair as necessary according to manufacturer's instructions.
2. Rinse probe and cable with Deionized water.
3. Prepare probe and DO meter in accordance with instrument manufacturer's operating procedures (in meter box). Make certain probe contains sufficient electrolyte and the oxygen sensor membrane is in good repair.
4. Calibrate probe and meter using the fresh water - air calibration method. Correct calibration value for temperature and altitude; adjust meter accordingly.
5. When possible place probe directly into the stream, or water to be measured. If not possible, place probe into beaker filled with sample immediately after collection. Manually raise and lower probe through sample to remove any air bubbles that may be present. Allow sufficient time for probe to stabilize to sample temperature and dissolved oxygen concentration.
6. Read dissolved oxygen value. Record appropriate data on field forms.

STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF OXIDATION REDUCTION POTENTIAL (ORP)

1. Inspect the instrument and the probe to insure all parts, as listed in the owner's manual, are in the field case. It is very important that the ORP probe is in good condition.
2. Calibrate the ORP instrument in accordance with manufacturer's recommendations daily or more frequently if conditions warrant. ORP is temperature sensitive. Temperature measurement during calibration should be recorded.
3. Decontaminate a sample beaker in accordance with SOP-20.
4. Rinse ORP electrode with deionized water and then with sample water prior to inserting into sample beaker.
5. Obtain sample of water using a method which minimizes agitation of the sample. The more the sample is exposed to oxygen, the more likely it is that erroneous data will be obtained. If possible, obtain an in situ measurement of ORP.
6. If extractive methods are used to obtain water samples, fill the sample beaker with sample water which has been recently evacuated from the well and, again, minimize agitation.
7. Immerse the ORP electrode in sample and allow several minutes for the probe to equilibrate with the water.
8. Obtain reading to nearest ten millivolts. Obtain sample temperature as well.
9. Record ORP reading with corresponding +/- sign and corresponding temperature on standardized field forms or in the field book. Note any problems such as erratic or drifting readings.
10. Rinse probe with deionized water and store according to manufacturer's directions.

STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF TURBIDITY

1. Obtain water sample in accordance with SOP-11 or by grab sampling, whichever is appropriate for site conditions.
2. Decontaminate turbidimeter in accordance with SOP-20 and equipment manufacturer recommendations.
3. Calibrate turbidimeter in accordance with manufacturer's recommendations. Be certain to use calibration standards which bracket expected turbidity values and are within their expiration date.
4. Follow turbidimeter manufacturer instructions for placing sample in measurement chamber and obtaining measurement. Obtain turbidity measurement from collected sample as soon after sampling as possible.
5. Record data on standardized field forms.
6. Decontaminate turbidimeter in accordance with SOP-20 and equipment manufacturer recommendations.

STANDARD OPERATING PROCEDURE

FIELD SAMPLE FILTRATION

Filtration equipment should include either disposable 0.45 micron filters or glassware to field filter water samples through a 0.45 micron filter paper. Visually inspect filtration equipment for damage. Replace parts or repair equipment as necessary.

Disposable Filter Cartridge Method (Bailer or Peristaltic pump)

- A. Disposable Bailer
- i. Obtain sample water in disposable bailer.
 - ii. Affix disposable 0.45 micron filter cartridge to bailer inlet.
 - iii. Place labeled sample container beneath filter cartridge.
 - iv. Allow sample water to gravity drain from bailer through filter into sample container.
 - v. Use small quantities of filtered water to rinse sample container three times.
- B. Peristaltic Pump
- i. Fill disposable vessel with sample water.
 - ii. Affix disposable 0.45 micron filter cartridge to appropriate disposable tubing.
 - iii. Install appropriate disposable tubing into peristaltic pump.
 - iv. Insert non-filter end of disposable tubing into the sample vessel.
 - v. Place labeled sample container beneath filter cartridge.
 - vi. Turn peristaltic pump on and pump a small quantity of filtered water to rinse sample container three times.

Fill labeled sample container to appropriate level with filtered sample and mark level with permanent marker. Add appropriate preservative, if necessary. Invert sample container several times to insure complete sample - preservative mixing.

If extremely turbid sample water is obtained, use same procedure using a pre-filter (usually 3.0 or 5.0 micron paper) followed by 0.45 micron filtration.

Vacuum-type Method

1. Vacuum-type filtration apparatus will be decontaminated in accordance with SOP-20.
2. Place 10-15 milliliters of 10% dilute nitric acid into filter apparatus containing 0.45 micron filter. Apply vacuum, discard filtered solution.
3. Repeat above procedure three times using sample water. Discard filtrate. If unable to repeat three times, use a pre-filter before using the 0.45 micron filter.
4. Fill filter vessel with sample water and apply vacuum. Use small quantities of filtered water to rinse sample container three times.
5. Fill labeled sample container to appropriate level with filtered sample and mark level with permanent marker. Add appropriate preservative, if necessary. Invert sample container several times to insure complete sample - preservative mixing.

6. Place sample container into cooler; package and ship in accordance with SOP-19.
7. If extremely turbid sample water is obtained, use same procedure using a pre-filter (usually 3.0 or 5.0 micron paper) followed by 0.45 micron filtration.
8. Decontaminate all equipment in accordance with SOP-20 following use.

STANDARD OPERATING PROCEDURE

FIELD PRESERVATION OF WATER SAMPLES

1. Collect the sample according to the appropriate SOP.
2. If sampling for dissolved metals, field filter sample according to SOP-14.
3. Pour sample into the appropriate sample containers.
4. Add necessary preservative volume as directed by contract laboratory. Sample preservatives and volume depend on analyses to be conducted, consult contracted laboratory. Also see ("Handbook for Sampling and Sample Preservation of Water and Wastewater", EPA-600/4-82-029; "Guidelines Establishing Test Procedures for the Analyses of Pollutants Under the Clean Water Act", 40 CFR 136; and "Test Methods for Evaluating Solid Wastes," EPA SW-846).

A few common sample preservatives are listed below:

Dissolved Metals	Add 3-4 ml. Nitric Acid to 500 ml. sample
Nutrients	Refrigerate to 4°C; Add 3-4 ml. Sulfuric Acid to 500 ml. sample
Common Ions	Refrigerate to 4°C
Hydrocarbon VOA	Refrigerate to 4°C; Add 3-4 drops HCl*
Diesel Range Organics	Refrigerate to 4°C; Add 80 drops (4ml) H ₂ SO ₄
Fluorescent Tracer Dye	Refrigerate to 4°C; Prevent exposure to light

For additional bottling and sample preservation information, consult contracted laboratory.

5. Once preservative has been added to sample, or sample added to pre-preserved bottle, tightly seal container and invert several times to assure complete mixing.
6. For volatile analyses add preservative to sample vial and fill vials at the rate of 100 milliliters per minute (24 seconds for 40 milliliter vial); form positive meniscus over vial brim and cap. After capping, invert vial, gently tap and look for air bubbles. If bubbles are present, un-cap vial, add more water and repeat procedure.
7. Certain conditions can require an increase in the amount of acid preservative needed.
 - Suspended sediment, especially calcareous material, can neutralize the acid and act as a buffer. This will cause a release of CO₂ when acid is added.
 - Bacteria or organic material can act to neutralize the acid and adjust the pH of the sample.
 - The presence of chemical buffers in the sample can affect the effectiveness of the acid preservative and suppress changes in pH.

***Note: Adding more than 4 drops of HCL to standard 40 ml VOA vials may create chlorinated hydrocarbons and should only be done after consulting with the contracted laboratory.**

STANDARD OPERATING PROCEDURE

QUALITY CONTROL (QC) SAMPLES

Quality Control (QC) samples are submitted along with natural samples to provide supporting laboratory data to validate laboratory results. QC samples typically are submitted blind, and do not have any unique identifying codes that would enable the lab or others to bias these samples in any way. Usually, the time or sampling location is modified in a way which will separate blank and standard samples from the rest of the sample train. QC samples are identified only on field forms and in field notebooks. The following codes are typically used:

N - Natural Sample	Soil, water, air, or other material from a field site
SP - Split Sample	A portion of a natural sample collected for independent analysis; used in calculating laboratory precision
D - Duplicate Sample	Two samples taken from the same media under similar conditions; also used to calculate laboratory precision
BB - Bottle Blank	Distilled water collected in sample bottle; used to detect contamination in sample containers
CCB - Cross Contamination Blank	Distilled water run through decontaminated equipment and analyzed for residual contamination, also known as a Rinsate blank
BFS - Blind Field Standard	Certified chemical constituent(s) of known concentration; used to determine laboratory accuracy
TB - Travel or Trip Blank	Inert material (deionized water or diatomaceous earth) included in sample cooler; sent by the lab, the sample is used to determine if contamination by volatiles is present during collection or shipping

In general, selected QC samples will be inserted into the sample train within a group of 10 to 20 samples. Unless otherwise specified, QC samples will be prepared in the field. Distilled water for bottle blanks and cross-contamination blanks will be collected from carboys and cubitainers used in the field. An exception to field preparation of QC samples is some blind field standards. Since the analytes in some blind field standards are to be mixed according to specific manufacturer's instructions, field conditions may not provide the needed laboratory atmosphere. This is especially true for volatile organic compounds, which need to be prepared just before analyzing. Under these circumstances, such blind field standards will be shipped to the laboratory for preparation, keeping the concentration or manufacturer's QC Lot Number as blind as possible.

The number and types of samples submitted for each group of natural samples will be determined by the project manager and others, including state or Federal agencies, and will be defined in the project work plan. Each field crew leader will be responsible for all QC samples prepared in the field.

Methods for computing data validation statements can be found in EPA documents or obtained from the laboratory.

STANDARD OPERATING PROCEDURE

FIELD FORMS / FIELD NOTES

All pertinent field investigations and sampling information shall be recorded on a field form or in a hard bound field book during each day of the field effort and at each sample site. The field crew leader shall be responsible for ensuring that sufficient detail is recorded on the field forms. No general rules can specify the extent of information that must be entered on the field form. However, field forms shall contain sufficient information so that someone can reconstruct all field activities without relying on the memory of the field crew. All entries shall be made in indelible ink, weather conditions permitting. Each day's or site's entries will be initialed and dated by the author. At the end of each day, field notes will be finalized, with field personnel's signature and date at the bottom of the page. Field forms, field notes, and photographs will be scanned into the project directory on the project server as soon as possible upon return to the office.

At a minimum, entries on the field sheet or in field notebook shall include:

- Project name and type/project number
- Purpose/objective of site visit
- Date and time of starting work and weather conditions
- Names of field crew leader and team members
- Subcontractors present or other visitors
- Health and safety tailgate topics
- Location of sample site, including map reference, if relevant
- Description of site conditions and any unusual circumstances
- Equipment ID numbers or serial numbers, including equipment calibration information (standards used, verification reading values, drift check values, or reference to location of calibration information. Date/time of calibration shall be recorded in the field book or designated field form)
- Details of actual work effort, particularly any deviations from the field work plan or standard operating procedures
- Chronologic description of observations and events
- Persons contacted and topics discussed
- Field observations
- Any field measurements made (e.g., pH) with time entry of measurement and units of measurement, or reference in field book to standardized field form

For sampling efforts, specific details for each sample should be recorded using Tetra Tech standardized

field forms. Surface water and groundwater field forms contain fill-in-the-blank type information in order that all pertinent information shall be recorded. In addition to the items listed above, the following information is recorded on field forms during sampling efforts:

- Time and date samples were collected
- Number and type (natural, duplicate, QA/QC) of samples collected
- Analysis requested
- Sampling method, particularly deviations from standard operating procedures
- Observations of sampling point conditions

Strict custody procedures shall be maintained with the field forms. Field forms shall remain with the field team at all times, while being used in the field. Upon completion of the field effort, photocopies of the original field forms will be made and used as working documents; original field forms shall be filed in an appropriately secure manner.

Photographs

Photographs should be taken using a camera lens similar to the naked eye. Wide angle and telephoto photos are not legal representation. Some clients do not permit these on site photographs. Confirm with project manager or site representative whether photographs are allowed. Reference each photograph in the field book or field form noting the direction and object of view. Photographs are to be uploaded to the project directory after the work is completed.

Corrections

In the event an error is made on the field form or in the field notebook, corrections will be made by drawing a single line through the error then enter the correct information. All corrections will be initialed and dated.

STANDARD OPERATING PROCEDURE

SAMPLE DOCUMENTATION

Sample documentation is an important step to ensure the laboratory, project manager, and field personnel are informed on the status of field samples. Depending on the specifics required for each project, a number of forms will need to be filled out. Some sample documentation forms are preprinted carbonless triplicates, enabling copies to be filed or mailed from labs or offices. The forms will be completed by field personnel, who have custody of the samples. The office copy will be kept in the project file and subsequent copies sent to the laboratory, or other designated parties. The responsibility for the completion of these forms will be with each field crew leader. It is important the field crew leader is certain field personnel are familiar with the completion process for filling out forms, and the expected information is included.

Potential documents to be completed clearly using indelible ink for each sample generated include:

- Sample Labels

Sample identification are required on all sample containers. Labels should contain the following:

- Sample identification
- Date and time of sample collection
- Analysis to be performed
- Preservative
- Project name
- Sampler's initials

Note: when sampling for volatile organic compounds, tape should not be used to cover any label due to potential for volatile organics in the tape adhesive to contaminate the sample. Care should also be taken to use Sharpie pens in well ventilated areas due to possible toluene contamination of the sample.

- Field Form

Complete appropriate forms to document information associated with sample or sample site conditions. All form blanks are to be completed.

- Chain-of-Custody (COC)

The intent of COC is to apply traceability of sample from the time it is collected until its derived information is used. COC information includes the following:

- Sample identification
- Sample matrix
- Number of containers
- Sample date and time
- Preservation
- Project name
- Samplers name
- Date, time, and person responsible for sample integrity
- Contact information of project manager or person responsible for sample results

- Custody Seal, signed and dated by the person relinquishing custody

If working on Superfund activities, the following additional forms will also be prepared:

- EPA Sample Tags
- SAS Packing Lists
- Sample Identification Matrix Forms
- Organic Traffic Report (if applicable)
- Inorganic Traffic Report (if applicable)

STANDARD OPERATING PROCEDURE

EQUIPMENT DECONTAMINATION

The purpose of this SOP is to describe general decontamination procedures for field equipment in contact with mine/mill tailings, soil, or water. During field sampling activities, sampling equipment has potential to become contaminated through use. Sampling equipment must be decontaminated between sample collection points if it is not disposable. Field personnel must wear disposable nitrile or vinyl gloves and eye protection while decontaminating equipment at the project site. Change gloves between every sample. Every precaution must be taken by personnel to prevent contaminating themselves with the wash water and rinse water used in the decontamination process.

Table A-1 lists equipment and liquids necessary to decontaminate field equipment.

TABLE A-1. EQUIPMENT LIST FOR DECONTAMINATION

5-gallon plastic tubs	Liquinox (soap)
5-gallon plastic water-container	Hard bristle brushes
5-gallon carboy DI water	Garbage bags
1-gallon cube of 10% HNO ₃	Latex or nitrile gloves
1-gallon container or spray bottle of	Spray or squeeze bottles
10% Methanol for organics	Paper Towels

Distilled water may be purified through a distilling process or a reverse osmosis (RO) process. The RO process is preferred if sampling for metal contaminants.

The following should be done in order to complete thorough decontamination:

1. Set up the decontamination zone upwind from the sampling area to reduce the chances of windborne contamination.
2. Visually inspect sampling equipment for contamination; use stiff brush to remove visible material.
3. The general decontamination sequence for field equipment includes: wash exterior of non-dedicated equipment with Liquinox or an equivalent non-phosphate degreasing detergent; follow with a distilled water rinse; follow with 10% dilute nitric acid rinse (if sampling for metals) or 10% methanol solution (if sampling for organics); follow with a distilled water rinse.
4. Wash interior of sample equipment with the same sequence as above. For pumps, pump decontamination solutions through the device and purge decontamination solutions with the next sample water prior to collecting the next sample.

Alternatively, field equipment can be decontaminated by steam cleaning, rinsing with 10% dilute nitric acid (if sampling for metals) or 10% dilute methanol (if sampling for organics), and rinsing with distilled water.

All disposable items (e.g., paper towels, latex gloves) should be deposited into a garbage bag and disposed of in a proper manner. Contaminated wash water does not have to be collected, under most circumstances.

If vehicles used during sampling become contaminated, wash both inside and outside as necessary.

STANDARD OPERATING PROCEDURE

MONITORING WELL CONSTRUCTION

Many states require certification and licensing for monitoring well drillers. Be sure you know the State's regulations before arriving on-site, especially if drilling outside your own State.

1. Safety equipment required on-site of the drill rig is mandatory. Personal protective equipment includes (at a minimum): hard hat, ear plugs, safety glasses, steel toed boots, gloves, first aid kit, and site safety plan - with routes to hospitals known by all personnel on-site.
2. Arrive on-site with properly sized drilling equipment and materials for site conditions. All drilling equipment and materials should be properly decontaminated prior to its arrival on-site. Decontamination usually includes steam - or hot water-cleaning methods.
3. Drilling muds or drilling solutions of any kind are not to be used during drilling activities in conjunction with monitoring well construction. Acceptable drilling techniques include air-rotary, cable tool, hollow-stem auger or sonic. If unconsolidated material is encountered, it may be necessary to drive steel casing during drilling to maintain borehole integrity. It is suggested threaded steel casing be used in lieu of welding joints together to minimize this source of potential well contamination. Hydraulic jacks or the drill rig can be used to pull back the steel casing following emplacement of plastic casing.
4. A detailed lithologic log shall be completed during drilling activities. Water bearing characteristics of the formations should also be denoted on the log. In addition, details of monitoring well construction should also be described on the well log including total depth, perforated interval, sizes and types of construction materials, etc.
5. Seven- or ten-inch outside diameter hollow-stem augers can be used in drilling shallow exploration drill holes in many situations. Care is taken to avoid contamination due to oil and grease from the drill rig and split spoon sampler. Appropriate decontamination of the drill rig between drill holes is performed. Soil and sediment samples are collected using a standard 1.4 inch inside diameter split spoon sampler and a 140 pound drive hammer. The number of blows necessary to obtain an 18 inch length of sample is recorded on the exploration log. Appropriate decontamination of the split spoon sampler is accomplished between samples.

Either a single- or multi-completion monitoring well can be constructed in a single borehole where hollow-stem auger drilling is not used. Backfill with chemically-inert silica sand to above the perforated interval and emplace a bentonite plug above the sand. Install factory-screened and blank PVC (or stainless steel or PTFE for organics) well casing into the borehole. Where appropriate, begin pulling temporary steel casing out of borehole. Emplace silica sand above and below any perforated sections in the borehole; install bentonite plugs above and below sand pack around perforated sections. Backfill remaining well annulus with a bentonite slurry or with grout to the surface. Monitoring well development is presented in SOP-22.

6. Place locking well protector over PVC casing(s) after outer steel casing has been removed from the borehole if necessary. Place bentonite plug below bottom of well protector; grout well protector in place and lock with high quality lock.

STANDARD OPERATING PROCEDURE

MONITORING WELL DEVELOPMENT

1. Visually inspect all well development equipment for damage - repair as necessary.
2. Decontaminate all stingers, air hoses, surge blocks by scrubbing with brush and Liquinox solution, rinsing with dilute nitric acid solution, and rinsing with deionized water. If sampling for organics, replace the nitric acid rinse with 10% methanol as per SOP-20.
3. If using compressed air method for well development, make certain compressor utilized does not produce air laden with hydraulic fluid for lubricating purposes. This may affect the integrity of the monitoring well for producing viable water quality data.
4. Develop well by using surging techniques (surge block or bailer) followed by well evacuation. Repeat this procedure until evacuated water is visibly clean and essentially sand-free. In most cases, evacuated water can be disposed of on-site.
5. If specified in the project workplan, during evacuation process, collect water samples for field determinations of temperature, specific conductivity, and pH. Continue developing well until field parameters stabilize to within $\pm 5\%$ on three consecutive measurements.
6. Report field observations and volume of water removed on standard form.

STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF GROUND WATER LEVEL

1. Check well probe prior to leaving for field for defects by placing probe in water and testing buzzer and light. Repair as necessary.
2. Measure all wells (monitoring and domestic) from the top of the well casing in the north quadrant or from a designated measuring point, as appropriate. Measure and record distance from measuring point to ground level. Make sure measuring point is labeled on well, so future measurements can be made from the same location.
3. Obtain a depth to water from measuring point to the nearest hundredth of a foot by lowering the probe until the buzzer or light activates. Record data on appropriate field forms.

To avoid potential for introducing foreign constituents or entanglement with existing pump wiring on domestic wells, a sonic water level probe can be used following individual equipment instructions.

4. Decontaminate well probe between each measurement by rinsing with deionized water. (Note, sonic well probe does not need decontamination,) Additional decontamination, such as liquinox scrubbing, may be required for certain wells; consult the project work plan.
5. Measure all assigned project wells within a 24-hour period. Measure all assigned project wells prior to well purging/sampling activities are initiated.

STANDARD OPERATING PROCEDURE

DETERMINATION OF LIQUID HYDROCARBON THICKNESS IN WATER TABLE AQUIFER USING MONITORING WELL GAGING MEASUREMENTS

This procedure is used for estimating the actual thickness of a liquid hydrocarbon layer in a near-surface aquifer, using apparent liquid hydrocarbon thicknesses measured in a monitoring well under static conditions. The well must be screened throughout the entire interval from the uppermost liquid hydrocarbon level to a depth at which the liquid hydrocarbon level could potentially fall when the liquid hydrocarbon layer is bailed from the well, allowing for depression of the water level as some groundwater is inadvertently bailed from the well with the liquid hydrocarbon layer.

EQUIPMENT REQUIRED

1. A bailer with a diameter slightly smaller than the well to be tested, plus bailer cord.
2. A stopwatch.
3. A well gauging probe which can detect both water and liquid hydrocarbons, and which is accurate to at least 0.01 feet.*
4. A 5 gallon bucket, funnel and a D.O.T. approved 55 gallon drum.
5. Decontamination equipment.
6. Regular arithmetic graph paper, pencils and eraser, a scratch pad, field notebook, and a straight edge.

NOTE:* This technique requires accurate depth to water and liquid hydrocarbon measurements. The rapidity of these measurements requires a well gauging probe which is both fast and accurate, and does not present awkward or time consuming operating techniques. The dual interface probe design provides the degree of accuracy needed, while permitting the use of a single probe to gauge hydrocarbons and water. Use of two measurement devices can disturb liquid levels and will demand time for managing equipment at the expense of data collection. Since water level probes only provide half the data needed, another device would be needed to gauge liquid hydrocarbons. Tape and paste can serve this purpose but is awkward, slow and less accurate than an interface probe. Measurement techniques which disturb or affect the thickness or elevation of water or liquid hydrocarbons such as a clear acrylic bailer or a "plover" well gauge are not acceptable.

PROCEDURE

1. Decontaminate bailer and well probe as per SOP-20, or use a new disposable bailer.
2. Prepare a graph for recording measurements. The abscissa (X, or horizontal axis) will be used to record time of measurement. The ordinate (Y, or vertical axis) will be used to record depth to groundwater and depth to the liquid hydrocarbon layer.
3. Gradually lower the interface probe until the liquid hydrocarbon signal activates. Note this depth. Continue lowering the interface probe until the water signal activates. Note this depth. Gradually raise the interface probe until the hydrocarbon signal deactivates. This should be the same as the first reading. Plot the hydrocarbon and water readings at the Time Zero position on the Y axis of the graph

paper. The interval between the two readings is the Apparent Liquid Hydrocarbon Thickness in the monitoring well.

4. Bail the liquid hydrocarbon layer from the well. Bail as rapidly as possible. Take care to remove as little water as practical to avoid causing the water level in the well to fall significantly below the liquid hydrocarbon level in the aquifer. Attempt to remove all liquid hydrocarbons from the well. If this is not possible, bail until the no further reduction in liquid hydrocarbon thickness can be achieved. Place bailed hydrocarbons and water in the 5 gallon bucket for later transfer to the 55 gallon D.O.T. approved drum.
5. Immediately upon the cessation of bailing begin to measure and record depth to product, depth to water and time of measurement. Water and liquid hydrocarbon levels will change rapidly at first, then begin to slow with time. During the initial period of rapid liquid level change it will be necessary to take as many measurements as possible. An assistant who may record data as the individual gauging the well calls out measurements would be beneficial at this time.

As the rate at which changes in the thickness of the liquid hydrocarbon layer begins to slow, it will be possible to reduce the rate at which these measurements are taken. For example, after five minutes you may be able to take a reading every thirty seconds, after ten minutes the measurement rate may be reduced to once per minute, after fifteen minutes once per every five minutes may be sufficient etc...

6. The test is considered complete when the liquid levels in the well have stabilized for three consecutive readings, or when a significant amount of time has elapsed and liquid hydrocarbon thickness readings have approached 90 percent of the original liquid hydrocarbon layer thickness.
7. Plot the depth to water and depth to product measurements against the time elapsed since bailing was ended on the graph paper. Connect data points representing depth to water with a line. Connect depth to liquid hydrocarbon data points with a second line.
8. As the liquid level versus time data are plotted on the graph paper, certain trends will become apparent. The depth to water and depth to liquid hydrocarbon data plots will record the recovery of these fluids as lines (or curves) with a positive slope.

Initially, the thickness of the liquid product in the well will increase rapidly. After about one half to two hours, the rate of liquid hydrocarbon accumulation will decrease noticeably. Both of the lines connecting depth to water and depth to liquid hydrocarbon data points will then describe a less steep positive slope, or will become flat. This will be apparent as breaks in slope for each of the two lines representing fluid recovery rates. The liquid hydrocarbon thickness at the time of this break in slope is considered to represent the minimum estimated thickness of the liquid hydrocarbon layer in the aquifer.

A second break in slope will occur at a later time when the rate at which liquid hydrocarbons are accumulating in the well begins to increase again. At this time, the slope of the two lines will increase. The thickness of liquid hydrocarbons at this time represents the maximum theoretical thickness of liquid hydrocarbons in the aquifer.

The actual thickness of liquid hydrocarbons in the aquifer is therefore considered to range between the theoretical minimum and maximum hydrocarbon layer thicknesses represented by the earlier and later breaks in slope of the two lines depicting depth to groundwater versus time and depth to the liquid hydrocarbon layer versus time.

9. If these breaks in slope are not apparent following completion of the test, an alternate interpretation of the data may be used to estimate the true thickness of the liquid hydrocarbon layer. At the time when liquid hydrocarbons begin to accumulate in the well beyond the true thickness of the liquid hydrocarbon layer in the aquifer, the over accumulation of liquid hydrocarbons begins to depress the water table. This is represented by the generation of a negative slope in the line representing depth to groundwater readings. The thickness of the liquid hydrocarbon layer in the well at this time is considered to equal the true thickness of the liquid hydrocarbon layer in the aquifer.
10. Transfer bailed fluids from the 5 gallon bucket to the 55 gallon drum. Secure the 55 gallon D.O.T. approved drum for safe storage of recovered liquid hydrocarbons.
11. Decontaminate five gallon bucket, funnel, bailer and well probe as per SOP-20.
12. Complete field documentation of site activities before leaving the site.

STANDARD OPERATING PROCEDURE

GROUNDWATER SAMPLING

SUPPLIES – All Methods:

Five gallon bucket graduated in gallons	Decontamination equipment and fluids
Purge water containers – if required	- Liquinox or Alconox solution
Sample coolers and Ice	- 10% methanol solution (if sampling organics)
Preservatives (from laboratory, dependent on requested analysis)	- 10% nitric acid solution (if sampling for metals)
Filter apparatus (.45 micron)– if sampling for dissolved metals	- Distilled water
Field sampling forms and field log book	Personal Protective Equipment (PPE) – as required
Chain of custody (CoC)	- Nitrile gloves
Custody seals and packaging tape	- Safety glasses
Temperature blank – one per cooler	- Safety toe boots
Trip blanks for VOC or VPH	- Hardhat
Water level probe	Calibration fluids
Oil/Water interface probe (optional for hydrocarbons)	- 1413 mS common for specific conductance
pH meter ¹	- pH 4, 7, and 10
Temperature probe ¹	- Zobell solution or Quinhydrone (ORP)
Specific Conductance meter ¹	Tools
Oxidation Reduction Potential (ORP) meter ¹ (optional)	- Hose clamps, scissors,
Indelible marker	- screwdrivers, wrenches, duct tape, etc.
Garbage bags	

1 – Industry standard is use of a multiparameter meter containing all four parameters (temp, pH, SC, ORP, DO), and/or turbidity.

Method Specific Equipment

Calculator	500 mL poly bottle marked in 50 mL increments
Stopwatch	Pump control box with appropriate lines (tubing) and fittings
Bailer(s)	Air compressor or compressed nitrogen gas cylinder
Bailer rope/twine or teflon coated reel	Appropriate tubing air/nitrogen and water
Purge pump(s)	Tubing/reel rod apparatus
Discharge hose or tubing	Multi-parameter meter (pH, SC, temp, DO, ORP)
Generator	Turbidity meter and calibration standards
Fuel	Flow through cell

The intention of groundwater sample collection is to retrieve a representative sample of the aqueous portion of the aquifer at the time of collection. Numerous methods have been developed over time to retrieve as representative a sample as possible. Each method has advantages and disadvantages and specific equipment needs. The purpose of this SOP is to present how to collect groundwater samples using the various methods not the selection of the most appropriate method.

All sampling equipment shall be inspected for damage, and repaired if necessary, prior to arriving on-site. Pump and non-dedicated down-hole equipment is to be cleaned and decontaminated according to SOP-20 before use and between wells.

Follow manufacturer instructions to calibrate field meters before sampling.

GENERAL PROCEDURE

The General procedure for groundwater sampling is as follows

- 1) Wells shall be sampled from the least contaminated to more contaminated, if known.
- 2) Measure depth to water (SOP-23) - regardless of purge or sample collection method, measure static water level prior to initiating any purging or collection of samples. Puls and Barcelona (1995) recommend well depth be obtained from well logs. Measuring the bottom of the well casing will cause re-suspension of settled solids from the formation and require longer purging times for stabilization. Measure the well depth, if necessary, should be completed after sampling is completed. If sampling for hydrocarbons compounds, wells shall be checked for the presence of free product prior to purging and sampling (SOP-24).
- 3) Decontaminate non-dedicated down-hole equipment per SOP-20. The following is a summary of SOP-20: wash with Liquinox® detergent and tap water solution, followed with 10% volumetric methanol and distilled water solution (if sampling for organics) or a 10% volumetric nitric acid and distilled water solution (if sampling for metals), and finally distilled water rinses. Distilled water may be purified through a distilling process or a reverse osmosis (RO) process, or purchased from the grocery store.
- 4) Where possible and if known, sample wells in the order from least contaminated to most contaminated.
- 5) Purge well prior to sample collection by the method specified in the work plan or sampling and analysis plan (SAP);
- 6) Filter, containerize, and preserve as necessary groundwater samples for laboratory analyses.

The following table provides a brief summary of common purging and sampling methods, common application, advantages and disadvantages for general introduction of the methods presented in this SOP.

Method	Common Application	Advantages	Disadvantages
Purge 3-5 Casing Volumes	<ul style="list-style-type: none"> - Metals, inorganics - Inaccessible by other equipment - Insufficient water for submersible pump - Traditional historic method 	<ul style="list-style-type: none"> - May be faster/less expensive depending on purge method, volume, and depth - Some methods able to retrieve water from minimal water column 	<ul style="list-style-type: none"> - May produce large volumes of purge water - May affect chemistry of samples by surging, increased turbidity, mixing, excessive

		- Minimal training needed	drawdown
Purge to field parameter stabilization	<ul style="list-style-type: none"> - Metals, inorganics, organics with care - Inaccessible by other equipment - Insufficient water for submersible 	<ul style="list-style-type: none"> - May be faster/less expensive depending on purge method, volume, and depth - Some methods able to retrieve water from minimal water column 	<ul style="list-style-type: none"> - May produce large volumes of purge water, - May affect chemistry of samples by surging, increased turbidity, mixing, excessive drawdown.
Low-flow purge and sample	<ul style="list-style-type: none"> - Volatile organic compounds - Low-medium yield wells 	<ul style="list-style-type: none"> - Improved sample accuracy, - Reduced purge volume - Isolates stagnant water above screen - Samples represent naturally mobile contaminants 	<ul style="list-style-type: none"> - May take more than one hour per well to purge - Large amounts of disposable tubing consumed - Tubing and controls may freeze during cold weather. - High conductivity zones contribute more water may affect results - Will not work for very low yield wells - Bottle fill time may be lengthy - Equipment and process training needed
Passive – No purge sample	<ul style="list-style-type: none"> - Remote inaccessible locations - Stratification investigations - Selective organic sampling (diffusion sampling) 	<ul style="list-style-type: none"> - Minimal equipment and waste - Easy to use except on deep wells - Dedicated systems = no decontamination between wells - No purge water disposal - Can provide contaminant stratification data 	<ul style="list-style-type: none"> - Some systems have higher initial capital cost for dedicated systems - Some regulatory agencies may not accept - If sample absent during retrieval due to water level change, equipment or operation failure, may be days or weeks before resample. - Susceptible to vertical flow mixing in well

Three – Five Casing Volume Purge

If sampling for hydrocarbon compounds, wells shall be checked for the presence of free product prior to purging and sampling.

Purging must be performed prior to sample collection. Field parameters pH, specific conductivity, temperature will be measured on first purge water, after each casing volume is evacuated, and at the time of sample collection. Field parameters and purge volume values will be entered on Field Sampling Forms during the purge process. Additional field parameters to be measured such as oxidation reduction potential (ORP) may be identified in the work plan. Well purging may be achieved using bailers, inertial pumps, peristaltic pumps, bladder pumps, and submersible electric pumps. The specific purging method shall be chosen based on depth to groundwater, diameter of well, existing well configuration and contaminant(s) of concern. If using a pump, pump intake placement is dependent upon many variables such as the specific characteristics of the contaminant(s) targeted for sample analysis, contaminant(s) source and subsurface lithology to name a few. Review the site specific SAP for clarification of specific sampling protocols. The pump intake depth should meet the following criteria;

- Pump intake **must** be in the screened interval of the well casing;
- The pump should be placed to a depth that will ensure sufficient head is maintained for bladder recharge and DTW measurements;
- Pump intake should be placed at a depth consistent with previous monitoring activities;
- Pump should never be lowered to the bottom of the well; maintain 1-2 feet above well bottom minimum.

A minimum of three and up to five volumes of groundwater in the well casing shall be withdrawn prior to sample collection. The well is ready to be sampled when the specified number of casing volumes have been evacuated. The volume of water present in each well shall be computed using the length of water column and monitoring well casing inside diameter. The total volume of water in the well (gallons) can be approximated using the following formula (depth and water level measurements in feet; casing diameter in inches):

$$(1/25)(\text{Total Depth} - \text{Measured Water Level})(\text{Casing Diameter})^2 = \text{gallons}$$

If the recovery of a low-yield well exceeds two hours after purging, the sample shall be extracted as soon as sufficient volume is available in the well for a sample to be extracted. At no time will a monitoring well be purged dry if the recharge rate causes formation water to cascade down the well casing causing an accelerated loss of volatiles and change in pH.

During sample collection, sample directly from the bailer or pump tubing without altering pumping rate. Note: Pumping rate may be decreased if the pumping rate is too high to allow gentle non-turbulent flow into the container. If field filtering, install an in-line filter to the bailer or pump tubing and pre-rinse the filter with purge water prior to sample collection without stopping the purge process or follow SOP-14 as appropriate.

Complete sample documentation as necessary following SOP-17 and SOP-18.

Purge to Field Parameter Stabilization

If sampling for hydrocarbon compounds, wells shall be checked for the presence of free product prior to purging and sampling.

If specified by the project work plan, field parameters will be measured periodically during well purging. Field parameters, depth to water, purge volume values, and time, will be entered on Field Sampling Forms during the purge process. Well purging may be achieved using bailers, inertial pumps, peristaltic pumps, bladder pumps, and submersible electric pumps. The specific purging method shall be chosen based on depth to groundwater, diameter of well, existing well configuration and contaminant(s) of concern. If using a pump, pump intake placement is dependent upon many variables such as the specific characteristics of the contaminant(s) targeted for sample analysis, contaminant(s) source and subsurface lithology to name a few. Review the site specific SAP for clarification of specific sampling protocols. The pump intake depth should meet the following criteria;

- Pump intake **must** be in the screened interval of the well casing;
- The pump should be placed to a depth that will ensure sufficient head is maintained for bladder recharge and DTW measurements;
- Pump intake should be placed at a depth consistent with previous monitoring activities;
- Pump should never be lowered to the bottom of the well; maintain 1-2 feet above well bottom minimum.

The well is ready for sampling when measured field parameters stabilize at plus or minus five percent over three successive readings.

If the recovery of a low-yield well exceeds two hours after purging, the sample shall be extracted as soon as sufficient volume is available in the well for a sample to be extracted. At no time will a monitoring well be purged dry if the recharge rate causes formation water to cascade down the well casing causing an accelerated loss of volatiles and change in pH.

During sample collection, sample directly from the bailer or pump tubing without altering pumping rate. Note: Pumping rate may be decreased if the pumping rate is too high to allow gentle non-turbulent flow into the container. If field filtering, install an in-line filter to the bailer or pump tubing and pre-rinse the filter with purge water prior to sample collection without stopping the purge process or follow SOP-14 as appropriate.

Complete sample documentation as necessary following SOP-17 and SOP-18.

Low-Flow Purge and Sample

Groundwater samples collected using a low-flow (low stress) sampling system are completed accordance with U.S. EPA Standard Operating Procedure EQASOP-GW-001, last revised January 19, 2010. The low-flow method emphasizes the need to minimize hydraulic stress at the well-aquifer interface by maintaining low water-level drawdowns, and by using low pumping rates during purging and sampling operations (EPA 2010). The use of either a bladder pump or an adjustable rate electric submersible pump is recommended to purge and sample the wells while minimizing aeration and subsequent volatilization of constituents. Peristaltic pumps and other vacuum based pumps are not recommended but may be used with caution because they may cause degassing, pH modification, and loss of volatile compounds. The bladder pump method includes use of an air compressor or nitrogen compressed gas cylinder, controller and stainless steel bladder pump equipped with disposable down-well tubing to bring the water to the surface. The electric submersible pump includes use of a controller (with battery or portable generator), variable speed stainless steel submersible pump with disposal down-well tubing to bring the water to the surface. No matter which equipment is used to purge and sample, the discharge for each must go through a flow through cell to measure SC, ORP, pH, DO, and temp. The only field parameter that can be taken without a flow through cell is turbidity.

- 1) Wells shall be sampled from the least contaminated to more contaminated, if known.
- 2) Measure static water level prior to placing the pump in the well or collecting any samples (SOP-23). Puls and Barcelona (1995) recommend that well depth be obtained from well logs. Measuring the bottom of the well casing will cause re-suspension of settled solids from the formation and require longer purging times for stabilization. Measure the well depth, if necessary, should be completed after sampling is completed.
- 3) All non-disposable down-hole equipment will be decontaminated prior to sampling and between wells according to SOP-20. The following is a summary of SOP-20: wash with liquinox[®] detergent and tap water solution, followed with 10% volumetric methanol and distilled water solution (if sampling for organics) or a 10% volumetric nitric acid and distilled water solution (if sampling for metals), and finally distilled water rinses. Distilled water may be purified through a distilling

process or a reverse osmosis (RO) process. The RO process is preferred if sampling for metal contaminants.

- 4) The bladder pump intake will be lowered to a specific sampling depth that is selected for each well. Pump placement is dependent upon many variables such as the specific characteristics of the contaminate(s) targeted for sample analysis, contaminate(s) source and subsurface lithology to name a few. Review the site specific SAP for clarification of specific sampling protocols. The sampling depth should meet the following criteria;
 - o Pump intake **must** be in the screened interval of the well casing;
 - o The pump should be placed to a depth that will ensure sufficient head is maintained for bladder recharge and DTW measurements;
 - o Pump intake should be placed at a depth consistent with previous monitoring activities;
 - o Pump should never be lowered to the bottom of the well; maintain 1-2 feet above well bottom minimum.
- 5) Secure the pump/pump tubing to maintain a consistent pump intake level. Pump tubing should be dedicated, disposable tubing unless the well is fitted with a permanent, dedicated pump and tubing system.
- 6) Lower the electronic water level probe to 0.3 feet below the water table to monitor drawdown. Secure the probe to maintain a consistent monitoring level.
- 7) Connect the pump tubing to the flow-through cell and attach the multi-parameter meter probes.
- 8) Turn on the pump adjust the flow rate to minimize water level drawdown in the well (less than 0.3 feet). If the minimal drawdown that can be achieved exceeds 0.3 feet but remains stable, continue to purge. Measure or record pumping rate and collect water in a 5 gallon bucket to measure the total volume removed.
- 9) Use a 500 mL beaker or a 500 mL poly bottle marked off in 50 mL increments to measure mL/cycle.
- 10) Field parameters including pH, specific conductivity (SC), temperature, dissolved oxygen (DO), and oxidation-reduction potential (ORP) will be measured every 3 to 5 minutes during the purge process and at the time of sample collection using a multi-meter and flow-through cell. These parameters are used in the field to assess chemical stability prior to sampling. Measure water level at time of each parameter reading.
- 11) Stabilization is considered to be achieved when three consecutive readings, taken three to five minutes, apart are within a predetermined range as outlined below (summary of EPA's field parameter stabilization requirements).

EPA SOP GW-001 Requirements for Field Parameter Stabilization	
Parameter	Field Parameters Stabilization Requirements
Turbidity*	<5 NTU or $\pm 10\%$ when turbidity is greater than 5 NTUs
Dissolved Oxygen	10%, or values < 0.5 mg/l
Specific Conductance	$\pm 3\%$
Temperature	$\pm 3\%$
pH	± 0.1 unit
Oxidation Reduction Potential	± 10 mV

* - Turbidity levels of less than 5 NTU and stable drawdowns of less than 0.3 feet are preferred but not mandatory.

- 12) Field measurement data and notes will be recorded on groundwater sampling field forms. Record all field parameters, start time, flow rate, pump depth, water levels, time of parameters, water levels and the total volume removed from wells.
- 13) If field parameters have not stabilized with 90 minutes indicate such on the groundwater sampling field forms, and collect groundwater samples.
- 14) During sample collection, remove the flow through cell, and sample directly from the pumps tubing without altering the pumping rate. Note: Pumping rate may be decreased while collecting samples for VOC analyses if the pumping rate is too high to allow gentle non-turbulent flow into the container.
- 15) If Field filtering, install an in-line filter and pre-rinse the filter with purge water prior to sample collection without stopping the purge process or follow SOP-14 as appropriate.
- 16) Place samples in a cooler containing doubled, re-sealable bags filled with ice. Replenish ice as needed during the day, during transport, and prior to shipping to the laboratory.
- 17) Decontaminate all sampling equipment as per SOP-20.
- 18) Place disposable field sampling supplies in an approved waste receptacle for disposal at a sanitary landfill, unless specified otherwise in the work plan.
- 19) Complete sample documentation as necessary following SOP-17 and SOP-18.

Passive – No purge sample

There are several manufacturers of passive groundwater samplers. Passive samplers are generally classified as *Diffusion Samplers*, *Equilibrated Grab Samplers*, or *Accumulation Samplers*. In general, passive samplers are deployed by lowering and suspending the sampler at a specified depth. After a period of equilibration (days, weeks, months) the sampler is brought back to the surface to retrieve the sample. Some systems require decanting the sample from sampler in to laboratory supplied bottles, while other systems ship the disposable sampler to the laboratory. Follow manufacture instructions to deploy samplers and retrieve samples.

Domestic Well Sampling

- 1) Turn-on household fixture closest to well (preferably an outside faucet) that is on the well-side of any household water conditioning device. Use a hose to direct the discharge to an appropriate location if necessary.
- 2) Using the above equation, calculate the volume of water to be evacuated. Measure the discharge rate from the faucet in a graduated 5 gallon bucket, or other suitable container, to compute the rate of discharge. Calculate the time needed to evacuate the predicted volume from the well. Record all measurements and calculations on field forms.
- 3) If specified by the project work plan, measure field parameters. Continue monitoring field parameters periodically during purging process. The well is ready for sampling when either or both of the following conditions are met: 1) the purged volume is equal to three to five casing volumes and/or, 2) measured field parameters are within plus or minus five percent ($\pm 5\%$) over three successive readings.
- 4) Samples should be collected directly from hydrant or faucet and prior to entry of the water through any water conditioning devices. Do not collect samples through rubber hoses. For inorganics samples, rinse sample containers, without preservatives, three times with sample water before final collection. Do not rinse containers for organics analysis.
- 5) If sampling for dissolved metals or metals speciation, field filter sample according to SOP-14.
- 6) If sampling for volatile analyses gently fill vials; form positive meniscus over vial brim, add preservative, and cap. After capping, invert vial, gently tap and look for air bubbles. If bubbles are

present, un-cap vial, add more water and repeat procedure.

- 7) Add preservatives as necessary in accordance with SOP-15 or as directed by the laboratory.
- 8) Complete sample documentation as necessary following SOP-17 and SOP-18.

REFERENCES:

Puls, R.W. and Barcelona, M.J., 1995. Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. USEPA Office of Research and Development, Office of Solid Waste and Emergency Response. EPA/540/S-95/504, December.

U.S. EPA Standard Operating Procedure No. GW-0001, Revision 3, Revised January 19, 2010. Note, next revision anticipated in 2017 or 2018.

STANDARD OPERATING PROCEDURE

SOIL SAMPLE COLLECTION

This Standard Operating Procedure (SOP) describes the field equipment and sampling methods for surface and subsurface sampling of soil material. Methods explained in this SOP may be different from those identified in a project specific Sampling and Analysis Plan (SAP) or work plan. The project specific SAP or work plan should be referenced for additions or deletions to the methods noted below. All sampling equipment should be decontaminated using the procedures in SOP-20 before arriving on site.

Generally, for risk assessment decision making the top 1-inch of soil is considered surface soil representative of human health risks. For cleanup purposes, composite samples should be collected at equal depths of 6-inch intervals to a depth of 24-inches. Site specific conditions may require deeper sampling to determine vertical extent. Refer to project specific sampling and analysis plan (SAP) or work plan for required depth interval sampling.

FIELD EQUIPMENT

- Shovel
- Stainless steel mixing bowl and sampling trowel
- Hand lens (10) power
- Steel tape (10 foot minimum)
- Munsel color book (optional)
- No. 10 sampling screen
- Field forms and field book
- XRF (optional)
- Bucket augers

SURFACE SAMPLING

The objective of sampling is to collect representative samples to accurately characterize site conditions at a given time and location. Selection of sample location will depend on the goal(s) of sample collection. Common approaches for selecting sample location and/or spacing include: random, judgmental, systematic grid, and transect.

Random - arbitrary selection of location within the area of interest.

Judgmental – Subjective selection of location based on historical information, site conditions, and professional judgement.

Systematic grid – Division of area into equally sized squares or triangles then collect samples from point of intersecting grid lines. Distance between locations is determined by the total area and the number of samples to be collected.

Transect – Establish one or more transect lines across the area and collect samples at regular intervals along each line. Transect lines may be parallel (similar to systematic grid) or non-parallel to follow a linear feature such as a ditch.

Each location selected for soil sampling (i.e. residential lot, playground etc.) should be divided into approximately equal areas not to exceed 2,500 square feet unless defined otherwise in the SAP or work plan. From each of these areas, grab samples will be collected from five equally spaced locations.

1. Soil collection can be accomplished by scrapping the ground with a stainless steel or plastic trowel or spoon and deposited directly into a stainless steel bowl, plastic tub, or resealable polyethylene bag (i.e. Ziploc or equivalent) where it will be mixed and any clods broken up. When sampling soil for organics, the soil should not be mixed to avoid potential volatilization and sample bias.
2. At locations where grass or other vegetation is present, surface material is removed to the top of mineral soil and the prescribed depth interval sampled as described above.
3. The sample should be screened with the 10 mesh sieve if coarse fragments are to be excluded from the sample.
4. Each composite sample should consist of equal amounts of soil from individual grab sample locations.
5. All grab samples for a composite should be collected from the same depth interval.
6. To select a sample from the mixing container, quarter the sample in the container and place an equal volume of soil from each quarter in the laboratory sample container. Sufficient sample will be collected for the analysis that will be performed. Check with laboratory, SAP, or work plan prior to leaving the office for appropriate sample container type and volume. Soil samples will be collected in either laboratory supplied wide-mouth glass jars or resealable polyethylene bags (i.e. Ziploc or equivalent).
7. Pack sample into container eliminating as much void space as possible and seal the container.
8. If field screening for metals or organic compounds will be completed, it can be completed on the residual homogenized sample or a split sample collected simultaneously as the laboratory sample. Field screening for metals using a X-Ray Fluorescence Spectrometer (XRF) may be completed following SOP-31. Field screening for organic compounds by an ionization device may be completed following SOP-32.
9. All necessary paperwork will be filled out in accordance with SOP-18. Samples should be described according to the procedures outlined in the Unified Soil Classification System (USCS; method ASTM D2488) or the United States Department of Agriculture – Natural Resource Conservation Service (USDA – NRCS) classification system, depending on project requirements. Soil texture should be classified by either the USCS or USDA classification. Descriptions shall be recorded in field books or on standard morphological description logs as provided in the SAP or work plan.
10. All equipment used in the sampling of surface soils will be decontaminated between sampling sites using the procedures in SOP-20.

Reference:

U.S. Environmental Protection Agency (EPA). 2003. Superfund Lead-Contaminated Residential Sites Handbook. OSWER 9285.7-50. August 2003. U.S. Environmental Protection Agency. Office of Emergency and Remedial Response.

U.S. Environmental Protection Agency (EPA). 1995. Superfund Program Representative Sampling Guidance Volume 1: Soil. OSWER 9360.4-10, EPA540/R-95/141, PB96-963207. December 1995. U.S. Environmental Protection Agency. Office of Emergency and Remedial Response.

SUBSURFACE SAMPLING

Subsurface sampling will be completed using a bucket auger, split spoon sampler, direct push sampler, hand dug, or backhoe excavated pits. Sampling procedures for each type of equipment is described below. Sample collection, homogenation, and transfer to sampling containers should follow the same procedures as outlined for collection of surface samples.

Bucket Auger

1. Arrive on-site equipped with stainless steel auger rod and several sizes of stainless steel bucket augers (e.g. 2-inch, 4-inch, 6-inch, etc.).
2. Bucket auger holes can be drilled as one size or in a telescoping manner if contamination between sample intervals is a concern. If a single size, advance the bucket auger to the desired sampling interval depth and empty the contents of the auger in a stainless steel mixing bowl. For the telescoping method, advance the largest auger to an approximate depth of three feet, collecting specified depth increment samples as the auger is advanced. Install temporary decontaminated PVC casing with a diameter slightly smaller than the borehole to keep the hole open and reduce possible cross-contamination between depth intervals. Using the next size smaller bucket auger, repeat the process.
3. Select sample intervals to be packaged for laboratory analysis in accordance with procedures described in the SAP or work plan. Pack the sample into container (glass jars or resealable polyethylene bags (Ziploc or equivalent) eliminating void space as possible and seal the container.
4. Fill out appropriate paper work and bottle labels as necessary prior to leaving site.
5. Decontaminate all equipment between sample locations.

Split Spoon Sampler

1. Arrive on-site equipped with at least two standard 1.4 inch inside diameter split spoon samplers (may be supplied by subcontracted driller). If geotechnical information is desired, a 140 pound drive hammer is also required.
2. Install sampler into borehole and advance to the desired depth with the 140 pound drop hammer or equivalent means. Record number of blow counts to complete sampling over each 18-inch interval, as necessary. Retrieve sampler and place on work table. Using the other sampler, repeat this sequence.
3. Record lithology as outlined in the Unified Soil Classification System (USCS; method ASTM D2488) or the USDA - NRCS classification system and document percent recovery from cores retrieved from split spoon sampler.
4. Based upon the project SAP or work plan, composite like core intervals by mixing in stainless steel bowl in a similar manner as described for surface sampling. When sampling for organics, the sample should not be mixed to avoid potential volatilization.
5. Pack sample into laboratory supplied container (glass jars or resealable polyethylene bags (Ziploc or equivalent) eliminating void space as possible and seal the container.
6. Decontaminate sampling equipment between each interval sampled if required by the SAP or work plan. Decontaminate sampling equipment between sampling sites.

Direct Push Technology (i.e. Geoprobe)

1. Arrive on-site with sample tube, adequate number of plastic sleeve tube liners, and required drive / retrieval equipment.
2. Install sample tube sleeve liner into sample tube and advance to the desired depth by appropriate drive mechanism. If desired depth is greater than sample tube length, retrieve sample tube, extract tube sleeve liner with sample, install new sleeve liner and continue advancing the original bore hole.
3. Place retrieved sample tube liner on work table. Using tubing sleeve cutter, cut sleeve open to access sample.
3. Record lithology as outlined in the Unified Soil Classification System (USCS; method ASTM D2488) or the USDA - NRCS classification system and document percent recovery from cores retrieved from sample tube.
4. Based upon the project SAP or work plan, collect soil for further analyses. When sampling for organics, the sample should not be mixed to avoid potential volatilization.
5. Pack sample into laboratory supplied container (glass jars or resealable polyethylene bags (Ziploc or equivalent) eliminating void space as possible and seal the container.
6. Dispose of plastic sleeve liners appropriately and decontaminate sampling tube between each interval sampled if required by the SAP or work plan. Decontaminate sampling equipment between sampling locations.

Backhoe or Hand Dug Excavations

1. Locate the site to be sampled and ensure that equipment can safely access the site. Minimize off road travel to prevent off site damage to surrounding vegetation.
2. Orient excavation to maximize use of the angle of the sun to illuminate the pit for photographs. Place excavated material a sufficient distance from the excavation as to eliminate sloughing or caving.
3. Excavate to the prescribed depth. If the pit exceeds five feet in depth, OSHA construction standards for shoring or sloping must be observed to prevent accidental burials. Sampling personnel should enter the pit with care during and after excavation.
4. Soil profile descriptions shall be made from a hand cleaned surface along the pit wall. Complete profile descriptions and take photographs before pit is sampled.
5. Soil samples shall be collected from depth intervals specified in the SAP or work plan. In larger excavations, generally one sample every 20 feet of pit wall or pit floor is recommended. When a depth interval is sampled, an equal volume of soil should be collected from the entire interval exposed on the pit wall. Soil samples will be collected with the stainless steel trowel and mixing bowl according to methods described for surface soil sampling. When sampling for organics, the sample should not be mixed.
6. Pack sample into laboratory supplied container (glass jars or resealable polyethylene bags (Ziploc or equivalent) eliminating void space as much as possible and seal the container.
7. After sampling is completed, the pit should be backfilled with clean material or with excavated material in the reverse order that it was excavated so that topsoil material is returned to the top of the pit. When backfilling is complete the area should be restored to its original condition as much as possible.

8. Decontaminate sampling equipment between sampling sites. Excavation equipment should be cleaned between sites with water (where possible) or with a shovel to remove accumulated dirt and mud.

STANDARD OPERATING PROCEDURE

IONIZATION DEVICE (PID or FID) OPERATION AND FIELD MEASUREMENT OF VOLATILE ORGANIC COMPOUNDS HEADSPACE

Equipment General

Ionization device (PID or FID)

Device accessories (regulator, tubing, filters, etc.)

Appropriate calibration gas

Sample containers (Ziplock re-sealable plastic bags or glass jars and aluminum foil)

Indelible pen or permanent marker.

INSTRUMENT OPERATION

1. Before taking the instrument to the field check the following:
 - Test the condition of the battery and recharge if necessary.
 - Make sure you have appropriate calibration gas in accordance with manufacturer recommendations and project work plan.
 - Check the integrity of the instrument and its accessories. Repair or replace broken parts and clean the sampling tip. On the PID clean the inlet filter.
 - Make sure you have all the accessories you will need for sampling.
 - If you are using the FID, check the hydrogen pressure and refill from the supply bottle if below 1000 psi.
 - If you are using the PID, check the expiration date on the span gas cylinder (normally 100 ppm isobutylene)
2. Arrive on-site with decontaminated equipment in working order. During transport, keep the instrument temperature stable and moderate.
3. Follow the manufacturer's instructions for starting up the instrument. Turn the instrument on and let it run for a few minutes, allowing the electronics to stabilize.
4. For the flame ionization detector (FID), let the electronics warm up for about 5 minutes and the pump to run for at least 3 minutes before attempting to light the flame. After lighting the flame, test the instrument with a known hydrocarbon (i.e., permanent marker etc.) to make sure the flame remains lit.
5. Calibrate meter before leaving for the field and each day in the field when headspace will be measured. Record results of calibration in the field book for the project in which the instrument is

being used. Calibrate the instrument by setting the zero and span against the calibration gases following manufacture instructions. To zero the instrument you may use clean air, if available, or a cylinder of compressed zero gas.

6. Complete your organic vapor readings and record the results according to the measurement method below.
7. Shut down the instrument according to the manufacturer's instructions. Decontaminate and carefully pack the instrument before leaving the site.

FIELD MEASUREMENT OF VOLITILE ORGANIC COMPOUND HEADSPACE

1. Place sample material in a Ziplock bag and seal. Mix contents in bag to break up soil clumps and homologize. Alternatively, place sample to be tested in clean canning type jar. Cover the sample tightly using aluminum foil and the outer ring of the jar lid. Be sure to mark container with sample location (boring/test pit # and depth).
2. Allow sample to come to room temperature (approximately 70 - 80° F) by placing in warm location not in direct sunlight. This can be accomplished by placing the container under the heater vent of the vehicle in winter or in a closed vehicle in summer.
3. Insert probe through foil or small opening in the Ziploc bag. Probe should be placed in container such that soil particles are not ingested into analyzer. Record maximum reading.

NOTE: Consistency in results is enhanced by using approximately equal portions of material, similar jar or bag sizes and similar test temperatures. Moisture content may also affect readings using some instruments.

MAINTENANCE

1. Disassemble and store meters in their case.
2. Charge batteries after each use as described in user's manual.
3. Occasional routine maintenance may be necessary ie. cleaning or replacing filters following manufacturer recommendations. Any maintenance you feel unqualified to perform should be handled by an authorized service representative.