2019 Groundwater Monitoring Program Work Plan

Beaver Creek Unit, Cannery Loop Unit, and Kenai Gas Field (BCU-CLU-KGF) Contaminated Sites
Kenai, Alaska
AFE: 1952574

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ACRONYMS AND ABBREVIATIONS

~	approximately
°C	degree(s) Celsius
>	greater than
<	less than
%	percent
µg/L	microgram(s) per liter
µS/cm	microSiemen(s) per centimeter
±	plus or minus
AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
AK	Alaska Method
AOGCC	Alaska Oil and Gas Conservation Commission
BCU	Beaver Creek Unit
BCU4 North	Beaver Creek Unit Pad 4 North
BCU4 South	Beaver Creek Unit Pad 4 South
bgs	below ground surface
BLM	Bureau of Land Management
Brice	Brice Environmental Services Corporation
BTEX	benzene, toluene, ethylbenzene, and xylenes
btoc	below top-of-casing
CLU	Cannery Loop Unit
CLU3	Cannery Loop Unit Pad 3
cy	cubic yard(s)
DRO	diesel-range organics
EPA	U.S. Environmental Protection Agency
GAC	granular activated carbon
GIS	geographic information system
GRO	gasoline-range organics
HCl	hydrochloric acid
Hilcorp	Hilcorp Alaska, LLC
HVE	high vacuum extraction
ID	identification number
KGF	Kenai Gas Field
lmsl	local mean sea level
LNAPL	light non-aqueous phase liquid
Marathon	Marathon Oil Company
mg/L	milligram(s) per liter
mL	milliliter(s)
mL/min	milliliter(s) per minute
MS	matrix spike
MSD	matrix spike duplicate
mV	millivolt(s)
NAVD88	North American Vertical Datum of 1988
NGC	natural gas condensate
NM	not measured
NTU	nephelometric turbidity unit(s)

ACRONYMS AND ABBREVIATIONS (continued)

Oasis	Oasis Environmental Inc.
PAH	polycyclic aromatic hydrocarbon(s)
PID	photoionization detector
PLSS	Public Land Survey System
PPE	personal protective equipment
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RRO	residual-range organics
SDS	safety data sheet
SLR	SLR International Corporation
SOP	standard operating procedure
TAH	total aromatic hydrocarbons
TAqH	total aqueous hydrocarbons
TLC	Teflon-lined cap
TLS	Teflon-lined septa
TSCA	Toxic Substances Control Act
UOCC	Union Oil Company of California
VOA	volatile organic analysis
VOC	volatile organic compound

1.0 INTRODUCTION

Brice Environmental Services Corporation (Brice) personnel will mobilize to the Kenai Peninsula to conduct annual and biennial groundwater monitoring activities at the Hilcorp Alaska, LLC (Hilcorp) Beaver Creek Unit (BCU) Pad 4, Cannery Loop Unit (CLU) Pad 3 (CLU3), and the Kenai Gas Field (KGF) Unit in the Kenai Peninsula (Figure 1). Figures 2, 3, and 4 (Appendix A) present the three operation units where groundwater monitoring activities will take place. The BCU project area includes BCU Pad 4 North (BCU4 North) and BCU Pad 4 South (BCU4 South) sites, and the KGF project area includes four pads (KGF Pad 14-6, KGF Pad 34-31, KGF Pad 41-7, and KGF Pad 41-18).

1.1 Purpose and Organization of Report

This Work Plan describes the 2019 groundwater monitoring activities to be performed at the BCU, CLU, and KGF operation units. Groundwater monitoring well survey, installation, and decommissioning activities at the sites are described in the Work Plan but may be conducted under a separate mobilization effort to maximize efficiencies with other projects in the Kenai Peninsula.

This information has been organized into the following sections:

- Section 1.0 introduces the document purpose and organization, contact information for key personnel, site summary information, regulatory criteria, and schedule summary.
- Section 2.0 summarizes health and safety considerations, including personal protective equipment (PPE) and evacuation routes.
- Section 3.0 describes project tasks, including field activities such as monitoring well inspection and maintenance, monitoring well gauging and analytical sampling, sample handling and chain-of-custody, waste management, and reporting.
- Section 4.0 provides site-specific details for BCU4 North and BCU4 South, including site conditions and analytical requirements.
- Section 5.0 provides site-specific details for CLU3, including site conditions and analytical requirements.
- Section 6.0 provides site-specific details for KGF pads 14-6, 34-31, 41-7, and 41-18, including site conditions and analytical requirements.
- Section 7.0 lists the references used throughout the document.
- Appendix A contains figures illustrating the site features, monitoring well locations, and groundwater flow directions.
- Appendix B provides the applicable Brice standard operating procedures (SOPs), including field documentation forms.

1.2 Key Personnel

Table 1-1 lists the key personnel involved in these project activities along with their association to the project and their contact information. Brice field personnel will coordinate with the Hilcorp BCU4, CLU3, and KGF health and safety representatives to complete site orientation and Wildlife Interaction Avoidance Plan requirements. Field personnel will also coordinate with the Hilcorp BCU, CLU, and KGF Foreman and Lead Operators to communicate work areas and schedule to avoid conflicts with simultaneous operations. The Brice Project Manager will communicate field progress and discuss any needs for Work Plan deviations with the Hilcorp Project Manager and the Alaska Department of Environmental Conservation (ADEC) Regulatory Specialist, as appropriate.

Table 1-1: Key Personnel

Name	Organization	Title	Phone Number	Email
Kelley Nixon	Hilcorp	Project Manager	907.777.8335 (O) 907.350.3524 (C)	knixon@hilcorp.com
Matt Hogge	Hilcorp	BCU, CLU & KGF Health and Safety	907.777.8418 (O) 907.227.9829 (C)	mhogge@hilcorp.com
Chris Walgenbach / Chad Johnson	Hilcorp	BCU, CLU, & KGF Foremen	907.283.1382 907.283.1325	cwalgenbach@hilcorp.com / cjohnson@hilcorp.com
Mike Chivers	Hilcorp	BCU Lead Operator	907.283.1316 907.283.1317	mchivers@hilcorp.com
Sean (Mac) Maguire / Kevin Cassidy	Hilcorp	CLU & KGF Lead Operators	907.283.1345 907.283.1305	smaguire@hilcorp.com kcassidy@hilcorp.com
Kimi Lloyd	Brice	Project Manager / Field Lead	907.275.2906 (O) 907.317.7999 (C)	klloyd@briceeng.com
Nicole Mattice	Brice	Environmental Engineer	907.243.4509 (O) 970.301.6960 (C)	nmattice@briceenvironmental.com
Mikayla Daigle	Brice	Geological Engineer	907.277.7291 (O) 715.966.1354 (C)	mdaigle@briceeng.com
Kelly Carson	Brice	Chemist	907.277.7297 (O) 907.350.6472 (C)	kcarson@briceenvironmental.com
Peter Campbell	ADEC	BCU & CLU Regulatory Specialist	907.262.3412	peter.campbell@alaska.gov
Paul Horwath	ADEC	KGF Regulatory Specialist	907.262-3422	paul.horwath@alaska.gov

Notes:
For definitions, see the Acronyms and Abbreviations section.

1.3 Summary of Sites

Table 1-2 summarizes the contaminated sites included in the 2019 groundwater sampling effort.

Table 1-2: Site Summary

Site Name	Wells	ADEC File Number	ADEC Hazard ID Number	2019 SITE SUMMARY					
				Wells to Be Sampled[1]	Wells to Be Gauged	LNAPL Socks to Be Installed/Replaced	Surface Water Points to Be Sampled	Wells to Be Decommissioned	Wells to Be Installed
BCU4 North	5	2320.38.081	26624	5	5	0	0	0	0
BCU4 South	17	2320.38.007	1005	12	17	2	0	0	0
CLU3	14	2320.38.012	2063	10	14	0	0	0	0
KGF Pad 14-6	29	2320.38.029	2434	22	29	2	8	2	0
KGF Pad 34-31	16	2320.38.031	3331	13	16	0	0	1	1
KGF Pad 41-7	16	2320.38.032	3191	15	16	2	7	12	6
KGF Pad 41-18	14	2320.38.033	3189	12	14	2	5	6	3

Notes:
For definitions, see the Acronyms and Abbreviations section.
[1] Primary samples only; quantity does not include QA/QC samples.

1.4 Regulatory Criteria

Groundwater analytical results will be evaluated against the ADEC levels presented in Title 18 of the Alaska Administrative Code (AAC), Chapter 75, Section 345 (18 AAC 75.345), Table C (ADEC 2018a). Analytical results for surface water samples will be used to calculate total aromatic hydrocarbons (TAH) and total aqueous hydrocarbons (TAqH), and these results will be compared to the criteria presented in 18 AAC 70.020 (ADEC 2018c). Current ADEC groundwater cleanup levels and surface water quality criteria are presented in Table 1-3.

Table 1-3: ADEC Table C Groundwater Cleanup Levels and Surface Water Quality Criteria

Analyte	ADEC Cleanup Level [1] [µg/L]
Petroleum, Oil, and Lubricants	
DRO	1,500
GRO	2,200
RRO	1,100
Petroleum-related VOCs (including BTEX)	
Benzene	4.6
Toluene	1,100
Ethylbenzene	15
Total xylenes	190
n-Butylbenzene	1,000
sec-Butylbenzene	2,000
Tert-Butylbenzene	690
Isopropylbenzene (cumene)	450
Naphthalene	1.7
1,2,4-Trimethylbenzene	56
1,3,5-Trimethylbenzene	60
PAH	
1-Methylnaphthalene [2]	11
2-Methylnaphthalene [2]	36
Acenaphthene	530
Acenaphthylene	260
Anthracene	43
Benz[a]anthracene	0.3
Benzo[a]pyrene	0.25
Benzo[b]fluoranthene	2.5
Benzo[g,h,i]perylene	0.26
Benzo[k]fluoranthene	0.8
Chrysene	2
Dibenz[a,h]anthracene	0.25
Fluoranthene	260
Fluorene	290
Indeno[1,2,3-cd]pyrene	0.19
Naphthalene	1.7
Phenanthrene	170
Pyrene	120
Other	
Ethylene glycol	40,000
Surface Water Quality Criteria [3]	
TAH	10
TAqH	15

Notes:
For definitions, see the Acronyms and Abbreviations section.
[1] Groundwater cleanup levels as defined by 18 AAC 75.345, Table C (ADEC 2018a).
[2] Not included in TAqH calculation.
[3] Surface water quality criteria from 18 AAC 70.020 (ADEC 2018c).

In 2017, volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAH) in groundwater were added to the list of analytes due to revisions to the ADEC *Field Sampling Guidance*, promulgated in July of 2017 (ADEC 2017a). In October 2018, ADEC revised 18 AAC 75, which included updates to cleanup levels for a number of analytes. Analytical results from the 2017 groundwater monitoring event were subsequently evaluated against the 2018 ADEC Table C cleanup levels (Brice 2019b; ADEC 2018a). Of the analytes added in 2017, only the analytes with results that exceeded the most current ADEC Table C cleanup levels were retained for sample analysis in 2019. Based on the analytical results of 2019 monitoring, analytes will be further refined for future work plans.

1.5 Schedule Summary

Table 1-4 presents the preliminary project schedule, including planned start and end dates.

Table 1-4: Project Schedule

Activity	Deliverable Submittal Date / Deadline
Work Plan Submission to ADEC	5/24/2019
Final Work Plan	6/24/2019
Fieldwork	6/26/2019 to 7/15/2019
Reporting	8/12/2019 to 11/18/2019

Notes:
For definitions, see the Acronyms and Abbreviations section.

2.0 HEALTH AND SAFETY

Brice personnel will follow company safety procedures including use of PPE appropriate to project locations and activities. Table 2-1 lists emergency resources in the project area.

Table 2-1: Emergency Contact Information

Resource	Name/Association	Contact
Emergency	Emergency Line	911
Hospital	Central Peninsula Hospital 260 Caviar Street Kenai, Alaska 99611	907.714.4536
Fire	Kenai Fire Department 105 S Willow Street Kenai, Alaska 99611	907.283.7666
Police	Kenai Police Department 107 S Willow Street Kenai, Alaska 99611	907.283.7879

2.1 Personal Protective Equipment

Field personnel will wear modified Level D PPE, consisting of the following:

- Hard hat
- Safety glasses
- Steel-toed boots
- High-visibility vest
- Gloves (leather or nitrile as appropriate)
- Fire resistant clothing and hearing protection (to be worn as required)

2.2 Site Safety and Health

Personnel will coordinate site work and schedules with the Hilcorp Lead Operator at each site. Upon arrival at the site, personnel will check in with the site office and participate in a site orientation and safety briefing. Work permits will be submitted as required by the Lead Operator. Hazards associated with groundwater and surface water sampling in the project area include remoteness of project locations, physical hazards, biological hazards, and chemical hazards.

2.2.1 Remoteness

Personnel will work in pairs and will maintain communication with the Hilcorp Lead Operators (checking in with the field office at the beginning and end of each work day) and the Brice project team (daily reports and cell phone contact as necessary) to ensure personnel safety.

2.2.2 Physical Hazards

Physical hazards include, but are not limited to, inclement weather; slips, trips, and falls; body strain; heat and cold stress; noise; and cuts. Weather hazards and potential for heat and cold stress will be mitigated by review of weather forecasts, frequent assessment for changing weather, and appropriate and layered clothing. Proper body mechanics will be employed to mitigate potential for body strain. PPE will be employed to mitigate other physical hazards, including noise, cuts, slips, trips, and falls.

2.2.3 Biological Hazards

Biological hazards may include insect bites and stings, reactions to plants, and encounters with wildlife. Personnel will review and comply with the Hilcorp Wildlife Interaction Avoidance Plan and will utilize repellent, netting, and protective clothing as necessary to mitigate exposure to insects and hazardous plants. First aid materials will be available and applied to treat bites, stings, and plant reactions as required. Personnel will work in pairs and will frequently assess their surroundings for wildlife. Air horns and bear spray will be available and employed as needed to deter interactions with wildlife. Personnel will take care to avoid wildlife interactions, such as releasing pulses on an air horn before entering areas of dense foliage and properly managing food waste and other wildlife attractants.

2.2.4 Chemical Hazards

Personnel may be exposed to petroleum-related contaminants such as diesel-range organics (DRO); gasoline-range organics (GRO); residual-range organics (RRO); benzene, toluene, ethylbenzene, and xylenes (BTEX); VOCs; and PAH. Detailed information regarding product identification, hazardous components, physical and chemical characteristics, fire and explosion hazard data, reactivity data, health hazards, precautions for safe handling and use, and control measures can be found in the associated safety data sheets (SDS). The SDS for each contaminant will be reviewed by every site worker prior to commencing work. If additional contaminants are suspected at a site, those SDSs will be evaluated as necessary.

3.0 PROJECT TASKS

Groundwater monitoring activities will be conducted by ADEC-qualified environmental professionals and will consist of the following:

- Monitoring well inspections and maintenance
- Monitoring well gauging
- Collection of groundwater and surface water samples
- Sample handling and chain-of-custody
- Decontamination of sampling equipment
- Waste management
- Field documentation

3.1 Monitoring Well Inspection and Maintenance

Monitoring wells will be inspected, including the outer monument, inner polyvinyl chloride (PVC) riser, locks, and bolts. The condition of the wells will be documented in the field logbook, including any present condition that may require maintenance (e.g., significant frost-heaving, locks that are broken or difficult to open, missing caps). In addition, maintenance may be performed and will be recorded in the field logbook. Where frost-heaving of the well hinders securing of the protective cap, the riser may be cut to shorten the well. Brice personnel will determine the northing, easting, ground surface elevation, and top-of-casing elevation for all monitoring wells with casings that have been shortened. At the conclusion of well maintenance activities, a list of any modified wells will be provided to the surveyor to reestablish top-of-casing elevations as necessary.

3.2 Monitoring Well Gauging Procedures

Groundwater levels will be measured in all monitoring wells to a precision of 0.01 foot relative to the mark on the well casing, or (in the absence of a mark) to the north side of the well casing using an electronic water level meter or oil/water interface probe. Depth to groundwater below ground surface (bgs), height of well riser above ground surface (stick up), depth to product (if present), and thickness of product (if present) will be measured and recorded. If no product is present, total well depth will be measured. All wells at a site will be gauged in a manner to minimize the time separating the gauge data between each well to allow more precise and representative data informing the interpreted groundwater contours. Measurements will be conducted in accordance with Brice Standard Operating Procedure BE-SOP-21 *Groundwater and Light Non-Aqueous Phase Liquid (LNAPL) Measurements* (Appendix B).

3.3 Monitoring Well Decommissioning, Installation, and Development

Wells scheduled for decommissioning or replacement will be decommissioned or installed and developed in accordance with BE-SOP-22, which describes monitoring well installation, development, and decommissioning activities (Appendix B). In addition, ADEC's *Monitoring Well Guidance* (ADEC 2013) will be used as a reference. Wells will be decommissioned by adding bentonite (chips or grout slurry) to the well to within 2 feet of ground surface after the bottom cap has been knocked out and the PVC riser and screen have been withdrawn above the groundwater interface. If bentonite chips are used, they will be hydrated to seal the well.

Well replacement (if necessary) will be achieved by first reviewing the existing well construction log to identify and evaluate design depth and screen length and to familiarize with local lithology. The wells will be installed either through the stem of auger casing or by direct push and will consist of 2-inch diameter, Schedule 40 PVC riser and a 0.010-inch slotted screen interval. The length of the screen will be determined based on the construction of the well being replaced. The area around the screened interval will be packed with sand and capped with a bentonite grout seal. Newly installed wells will have an aboveground-style completion unless site conditions and activity dictate that flush-mount completion is necessary.

Monitoring wells will be developed no earlier than 24 hours after well installation to allow for adequate hydration of the bentonite. The wells will be developed by cyclically surging with a surge block (the entire submerged length of the screen will be surged for approximately 10 minutes in each cycle) and pumping with a submersible pump, a peristaltic pump, or a bailer. Sediment will be removed from the bottom of the well and well screen by surging and removing water the full length of the well screen. Initially, heavy silt loading may require the use of a bailer. A minimum of three well casing volumes of water, plus twice the volume of water added during drilling and construction, will be removed. (Well casing volume is calculated from the borehole diameter and the length of screen below the water table and corrected for 30 percent porosity of the filter pack.) Monitoring wells will be considered developed after either the minimum volume of water has been purged, stabilization of field parameters (Table 3-1) has been achieved, or when the well has been purged dry. Wells will be sampled following development when either the groundwater has re-equilibrated to pre-purge elevation or the groundwater parameters have stabilized.

3.4 Analytical Sampling

The following subsections describe the procedures that will be used to collect and identify analytical samples, including quality assurance (QA)/quality control (QC) samples.

3.4.1 Groundwater Sampling Procedures

Groundwater samples will be collected from wells in accordance with low-flow sampling procedures based on U.S. Environmental Protection Agency (EPA) guidance (EPA 2017) and the ADEC *Field Sampling Guidance* (ADEC 2017a) and in accordance with BE-SOP-09 *Groundwater Sample Collection* (Appendix B). Monitoring wells will be purged and sampled using a submersible pump or bladder pump and disposable or dedicated tubing (depending on the well). If the well is unable to be sampled via submersible or bladder pump (e.g., obstruction, smaller diameter, or schedule PVC, etc.), the well may be sampled using a peristaltic pump, provided that volatile samples are collected in advance of the pump paddles (e.g., via T-valve attachment) or with an alternative sampling device such as a HydraSleeve.

Water quality parameters will be monitored continuously using a portable water quality meter, such as a YSI, and turbidimeter (BE-SOP-20). Purging will be complete when at least three water quality parameters (four when using temperature) have stabilized or when three well volumes have been removed from the well. Criteria for low-flow sampling are as follows:

- Drawdown during purging will be stabilized prior to sampling (less than 0.3 foot if possible).
- Low-flow rates are typically between 50 to 500 milliliters per minute (0.01 to 0.13 gallons per minute), but higher rates are consistent with low-flow guidelines as long as the drawdown requirement is met.
- Water quality parameters will be recorded as tabulated in Table 3-1.

Water quality parameters will be considered stable when three successive readings, collected 3 to 5 minutes apart, are within the criteria included in Table 3-1.

Table 3-1: Stability Criteria for Low-Flow Purging

Parameter	Units	Recording Precision	Stability Criteria	Typical Value Range for Stability Criteria
Temperature	°C	0.01	±3% (minimum of ±0.2°C)	0.1 to 15
pH	—	0.01	±0.1	5 to 8
Conductivity	µS/cm	1	±3%	80 to 1,000
Turbidity	NTU	0.1	±10% or < 10 NTU	0.3 to > 900
Oxidation-Reduction Potential	mV	1	±10 mV	-120 to 350
Dissolved Oxygen	mg/L	0.1	±10%	0 to 12

Notes:
For definitions, see the Acronyms and Abbreviations section.
Stability criteria from ADEC *Field Sampling Guidance* (ADEC 2017a).
Only three parameters are required to stabilize; four when using temperature.

Groundwater samples will be submitted to an ADEC-approved laboratory for analytical testing. Analytes for each groundwater sample are specified in the site-specific sections (Sections 4.0, 5.0, and 6.0), and the analytical results will be compared to ADEC Table C cleanup levels (refer to Table 3-2).

If a well is purged dry, it will be allowed to recharge for 24 hours or to 80% of its pre-purge volume. Without further purging, the well will be sampled (ADEC 2017a). If LNAPL is observed in a well, the thickness of the LNAPL will be documented, and the well will not be sampled. As applicable, LNAPL will be removed to the extent practicable, and LNAPL-absorbent socks will be installed or replaced.

3.4.2 Surface Water Sampling Procedures

Surface water samples will be collected from KGF Pad 14-6, KGF Pad 41-7, and KGF Pad 41-18. Surface water sample locations are identified on the site-specific figures in Appendix A (Figures 7, 9, and 10). Color, odor, and presence of sheen (or lack thereof) will be noted at each surface water sampling location in the field logbook. A clean container will be used to transfer surface water into the appropriate laboratory-supplied containers (depending on analysis). Surface water samples will be collected in accordance with BE-SOP-10 *Surface Water Sampling* (Appendix B), and the analytical results will be summed and compared to surface water quality criteria for TAH and TAqH in 18 AAC 70.020 (ADEC 2018c).

TAH and TAqH summations will be calculated using the limit of detection values for non-detect results, in accordance with the *Guidelines for Treatment of Non-Detect Values, Data Reduction for Multiple-Detections, and Comparison of Quantitation Limits to Cleanup Values Technical Memorandum* (ADEC 2017b). TAH is the sum of the results for the BTEX compounds (benzene, toluene, ethylbenzene, and xylenes). TAqH is the sum of TAH and the results for the 16 PAH compounds listed in EPA Method 610 (acenaphthene, acenaphthylene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenzo[a,h]anthracene, fluoranthene, fluorene, indeno[1,2,3-c,d]pyrene, naphthalene, phenanthrene, and pyrene).

3.4.3 Analytical Methods and Quality Assurance/Quality Control

Table 3-2 summarizes the analytical parameters, methods, containers, and preservation for groundwater and surface water sample collection.

Table 3-2: Summary of Analyses

Parameter	Method	Container Description	Preservation / Holding Time
Groundwater			
DRO/RRO	AK102/AK103	(2) 250-mL amber glass jar, TLC	HCl to pH<2, 0 to 6°C 14 days to extraction, 40 days to analysis
GRO	AK101	(3) 40-mL VOA vials, TLS	HCl to pH<2, 0 to 6°C 14 days
Petroleum-related VOCs including BTEX	EPA SW8260C	(3) 40-mL VOA vials, TLS	
PAH	EPA SW8270D SIM	(2) 250-mL amber glass jar, TLC	0 to 6°C 7 days to extraction, 40 days to analysis
Ethylene glycol	EPA SW8015C	(3) 40-mL VOA vials, TLS	0 to 6°C 14 days
Surface Water			
TAH/TAqH[1]	EPA 624	(3) 40-mL VOA vials, TLS	HCl to pH<2, 0 to 6°C 14 days
	EPA 625	(2) 250-mL amber glass jar, TLC	0 to 6°C 7 days to extraction, 40 days to analysis

Notes:
For definitions, see the Acronyms and Abbreviations section.
[1] TAH is calculated from the sum of the BTEX compounds; TAqH is calculated from the sum of TAH plus PAH compounds (as listed in Table 1-3 except 1-methylnaphthalene and 2-methylnaphthalene).

Field QA/QC samples will be collected and submitted at the following frequencies:

- Field duplicate samples will be collected and submitted at a frequency of one per day and one for every 10 or fewer field samples (whichever is more frequent), for each matrix and for each target analyte (10%). At a minimum, one field duplicate will be collected per site and per day of sampling at that site.
- Matrix spike (MS)/matrix spike duplicate (MSD) samples will be collected at a frequency of one MS/MSD set for every 20 or fewer field samples (5%). At a minimum, one MS/MSD sample will be collected per site.
- A trip blank will be submitted with each cooler containing samples for volatile analyses (GRO by AK101, petroleum-related VOCs by SW8260C, and VOCs by EPA 624).

These QA/QC sampling frequencies will be applied to each site individually; field duplicate and MS/MSD samples will not be shared between sites. Appropriate wells for duplicate and MS/MSD sample collection will be based on historical results and determined in the field based on such observations as well recharge and field indications of contamination. Samples will be segregated by site and submitted to the laboratory under separate chain-of-custody forms.

3.4.4 Sample Identification

The sample identification nomenclature for this project is defined below:

- The first set of characters identify the site
  - BCP4N represents BCU Pad 4 North
  - BCP4S represents BCU Pad 4 South
  - CLU3 represents CLU Pad 3
  - KGF146 represents KGF Pad 14-6
  - KGF3431 represents KGF Pad 34-31
  - KGF417 represents KGF Pad 41-7
  - KGF4118 represents KGF Pad 41-18

- The second set of characters identifies the well
    - e.g., MW4 identifies well MW-4
    - e.g., SW01 identifies the first surface water sample collected at that site
- The third set of characters identifies the month and year that the sample was collected
    - e.g., 0719 indicates July 2019

For example, a sample collected in July 2019 from well AP-4 at the BCU Pad 4 North site would be labeled "BCP4N-AP4-0719." Duplicate samples will be identified by a "Z" appended to the well designation; for example, a duplicate sample of the previous example would be labeled "BCU4N-AP4Z-0719."

3.5 Sample Handling and Chain-of-Custody

Following sample collection, jars will be sealed, labeled, and immediately placed in a cooler with gel ice to maintain a temperature between 0 and 6 degrees Celsius (°C). A temperature blank and a trip blank will be kept with the samples. A chain-of-custody will be prepared in accordance with BE-SOP-02 *Sample Chain-of-Custody* (Appendix B) and will accompany the samples from the time of collection until the samples are delivered to the ADEC-certified laboratory for analysis. Samples will be packaged and shipped to the analytical laboratory in accordance with BE-SOP-03 *Labeling, Packaging, and Shipping Samples* (Appendix B).

3.6 Decontamination

Reusable, non-dedicated sampling equipment requiring decontamination, including the electronic water level meter, pump, turbidimeter, and YSI, will be decontaminated between uses at each monitoring well. Disposable tubing will be used for purging and sampling in wells where dedicated tubing is not provided.

Decontamination will consist of washing the equipment with a mixture of potable water and Alconox, followed by a deionized or distilled water rinse. The water generated during decontamination activities of sampling equipment will be collected in U.S. Department of Transportation-approved 5-gallon buckets with screw-top lids, combined with purge water, and treated onsite through a granular activated carbon (GAC) filter. Wastewater will be poured into this GAC filtration unit and allowed to drain in a secondary container. The water will be visually inspected for sheen before being discharged to a vegetated area of the site at least 100 feet from drinking water sources and surface water bodies. If sheen is observed on the treated water, the water will be poured through the GAC and treated up to three times. If a sheen persists after three treatment cycles, the water will be segregated, labeled, and stored at Hilcorp KGF Pad 34-31 for appropriate disposal. Decontamination procedures are detailed in BE-SOP-14 *Equipment Decontamination* (Appendix B).

3.7 Waste Management

Investigation-derived waste will be generated during groundwater sampling activities including purge water, decontamination water, and general refuse (including nitrile gloves and other expended PPE, paper towels, and disposable tubing). Table 3-3 presents the anticipated waste streams, estimated quantities, and method of disposal for each waste stream.

3.8 Field Documentation

Fieldwork will be documented in field logbooks and groundwater sampling forms in accordance with BE-SOP-01 *Logbook Documentation and Field Notes* (Appendix B). Daily reports will also be provided to summarize daily activities and overall project progress. Field documentation will be appended to the final reports.

3.9 Reporting

After completion of field activities and receipt of all analytical laboratory data, a report will be submitted in draft and final versions. The content of this report will include the following:

- A summary of project goals and objectives
- A detailed description of completed field activities
- Analytical data tables
- An interpretation of the analytical data and a summary of the data quality and usability
- ADEC Laboratory Data Review Checklists
- Site figures
- Supporting field documentation
- Copies of the chains-of-custody, a sample summary, and cooler receipt forms
- A photographic log
- Conclusions and recommendations

Three draft reports detailing activities at each production unit will be prepared and provided to Hilcorp for comments. Comments will be incorporated into the final reports for submittal to ADEC and inclusion in the administrative record.

Table 3-3: Anticipated Waste Streams

Waste Stream	Waste Classification	Estimated Quantity	Container	Proper Shipping Name	Disposal	Notes
Liquid investigation-derived waste - No odor/sheen (purge water, decon water)	Non-TSCA/RCRA regulated	750 gallons (BCU: 140 gallons CLU: 70 gallons KGF: 540 gallons)	55-gallon drum	Non-hazardous liquid	GAC	Discharge GAC-treated water free of sheen to a vegetated, upland area of the site at least 100 feet from drinking water sources and surface water.
Liquid investigation-derived waste - Odor/sheen (Purge water, decon water)	Exempt	0 gallons	55-gallon drum	Non-hazardous liquid (hydrocarbon odor and/or sheen)	Hilcorp	Anticipate GAC treatment to be sufficient; however, in the event that odor and/or sheen are still observed after three GAC treatment cycles, this water will be containerized in 55-gallon drums, labeled, recorded on the KGF Ground and Inject Waste Log, and transferred to Hilcorp KGF Pad 34-31 for storage and subsequent disposal. These sites have sources relating to exploration and production and are, therefore, exempt.
Drilling Waste Soils	Exempt	<1 cy	55-gallon drum	Non-hazardous solid (hydrocarbon odor and/or staining)	Hilcorp	Soils unearthed during drilling activities will be placed downhole at the point of generation to the maximum extent practicable. Where there are no indications of contamination by visual, olfactory, or photoionization detector observation, excess soils that cannot be placed downhole will be landspread near the point of generation. Where field observations indicate the potential presence of contaminants, excess soils will be containerized in a 55-gallon drum, labeled, recorded on the KGF Ground and Inject Waste Log, and transferred to Hilcorp KGF Pad 34-31 for storage and subsequent disposal.
LNAPL (BCU)	Not Applicable	<5 gallons	5-gallon bucket with screw-top lid	Not Applicable	Recycle	Transfer to Hilcorp for recycling in the process stream.
LNAPL (KGF 14-6)	Exempt	<5 gallons	5-gallon bucket with screw-top lid	Waste oil	Hilcorp	Transfer to Hilcorp for disposal at the KGF Grind and Inject Facility.
LNAPL (KGF 41-7)	Non-exempt	<5 gallons	5-gallon bucket with screw-top lid	Waste oil	NRC	Transfer to Hilcorp for offsite disposal through NRC.
LNAPL-absorbent socks	Non-TSCA/RCRA regulated	2 "Oily Waste" bags	Polyethylene "Oily Waste" bags contained in 5-gallon bucket with screw-top lid	Oily waste	Hilcorp	LNAPL socks to be disposed of from BCU South, KGF Pad 14-6, and KGF Pad 41-7. Bags will be segregated by site.
Solid Waste	Non-TSCA/RCRA regulated	15 bags	Heavy 42-gallon garbage bags	Non-hazardous waste, solid (general refuse)	Local landfill	General refuse includes nitrile gloves and other expended PPE, paper towels, and disposable tubing. Document volume and transfer to local landfill or transfer station.
Spent GAC	Non-TSCA/RCRA regulated	55 gallons	55-gallon drum	Non-hazardous waste, solid (GAC)	Hilcorp	Hilcorp will facilitate disposal when no longer usable.

Notes:
For definitions, see the Acronyms and Abbreviations section.

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6.0 SITE-SPECIFIC INFORMATION – KENAI GAS FIELD

The KGF project area consists of four pads (KGF Pad 14-6, KGF Pad 34-31, KGF Pad 41-7, and KGF Pad 41-18), originally developed in 1959 by Union Oil company of California (UOCC) (Figure 4). Marathon acquired the KGF facilities in 1994. Hilcorp took over the pads in 2013 and is the current operator. The KGF pads are located approximately 60 miles southwest of Anchorage, Alaska, and 10 miles south of Kenai.

The following sections include site-specific information about site geology and hydrogeology, previous investigations on groundwater and/or surface water monitoring, well maintenance summary, and planned 2019 groundwater and surface water monitoring activities at KGF. Appendix A includes the figures presenting the sites, well locations, and surface water sample locations (as applicable).

6.1 KGF Pad 14-6

KGF Pad 14-6 is located centrally within KGF and less than a mile west of KGF Pad 41-7 (Figure 4). The KGF Pad 14-6 property lies within Salamatof Native Association, Inc. land on Kenai Peninsula Borough Tax Parcels 13103001 and 13103014. Gas recovery and transmission infrastructure are present on the pad along with several buildings, clustered on the southern half of the pad. Monitoring wells are located around the buildings and extend west into the native wetland, where surface water samples have been collected (SLR 2014a).

6.1.1 KGF Pad 14-6 Geology and Hydrogeology

KGF Pad 14-6 was constructed in the late 1950s and consists of a 3-to 4-foot gravel pad placed over native tundra, wetland, and spruce bog of the Kenai lowlands. The Kenai lowlands consist of topographically flat, discontinuous wetlands with organic soil from the surface to as deep as 6 feet bgs. Peat up to 5 feet thick can be found beneath the pad throughout most of the area. Beneath the organic soil layer lies a thin layer of fine-grained alluvium, then interbedded sand and sandy gravel to at least 17 feet bgs (SLR 2014a).

In 2017, groundwater elevations ranged between 61.63 and 64.52 feet (NAVD88) (57.84 and 60.53 feet above local mean sea level [lmsl]). Groundwater flow at KGF Pad 14-6 has historically been observed to vary between west-northwest and west-southwest during summer/fall sampling events. Groundwater elevation can fluctuate up to 5 feet seasonally (SLR 2014a). Groundwater flow direction was consistent with historical observations (west) in 2017 (Brice 2019b).

6.1.2 KGF Pad 14-6 Previous Investigation and Monitoring Activities

A hydrocarbon sheen was observed on the western edge of KGF Pad 14-6 in 1995 following a season of abnormally high precipitation. The incident was reported to ADEC by Marathon as a historical release; Marathon elected to initiate remedial efforts. Site assessment activities in 1996 and 1997 indicated the source of the sheen was natural gas condensate (NGC) associated with an unknown release; though it is of note that a historical leak at the Arctic Pipeline building ("APL #5 Building" on Figure 7) is documented on the ADEC Contaminated Sites Database (SLR 2014a).

Additional investigations at KGF Pad 14-6 were conducted to delineate the impacted area and conduct remedial actions. An LNAPL plume was discovered off the pad, south, and west of the former Retention Basin. Between 1996 and 2006, 41 monitoring and recovery wells were installed at the site, with groundwater monitored at varying frequencies. In 1998, approximately 1,100 cy of impacted soil was excavated from the source area and thermally treated. High-vacuum extraction (HVE) systems were installed to recover LNAPL in the source area and operated from 1998 to 2001 and 2003 to 2007. LNAPL-absorbent socks were installed in six wells in 2004 and 2005. A Membrane Interface Probe study was performed in 2006 as an in situ investigation to delineate LNAPL southwest of the pad (SLR 2014a).

Seven wells (MW-1, MW-2, MW-3, MW-13, MW-14, MW-15, and MW-21) at Pad 14-6 were observed to have increasing thicknesses of LNAPL from 2013 to 2014. These wells were incorporated into the HVE system and were inaccessible and unable to be gauged during the 2015 and 2017 monitoring events. LNAPL was detected in three wells (MW-23, MW-33, and MW-41) in 2017, but was not measured. Historically, MW-23 exhibited measurable LNAPL in 2013 (0.07 feet), 2014 (0.14 feet), and 2015 (0.13 feet) and detected but not measured LNAPL in 2017. LNAPL was first documented in MW-33 in 2015 (0.02 feet) and detected but not measured in 2017. LNAPL was first documented in MW-41 in 2014 (2.11 feet), an undetermined amount of viscous LNAPL documented in 2015, and detected but not measured LNAPL in 2017.

An HVE System LNAPL Recoverability Assessment in 2010/2011 concluded that the LNAPL plume near the Meter Building was no longer migrating laterally and was naturally attenuating. It would be impossible to hydraulically remove all LNAPL, due to emulsified LNAPL in groundwater and the presence of peat at varying depths. In 2010, an evaluation of groundwater-surface water hydrology was performed to determine the relationship between groundwater and surface water in the wetland southwest of KGF Pad 14-6. Despite shallow groundwater at the site, the evaluation found that LNAPL is not migrating to the ground surface in the wetland (SLR 2014a).

Groundwater monitoring conducted between 2013 and 2015 (evaluating concentrations of BTEX, GRO, DRO, and RRO) found concentrations of DRO, RRO, and benzene decreasing over time, indicating that the LNAPL plume is immobile and naturally attenuating. Calculated results for TAH and TAqH in surface water samples showed no petroleum hydrocarbon impact to adjacent surface water. It was recommended to sample groundwater and surface water biennially (SLR 2014a, 2015a; Brice 2016a).

The 2015 groundwater monitoring activities also observed measurable LNAPL in three monitoring wells (MW-23, MW-33, and MW-41). Groundwater depths measured during 2015 activities indicated groundwater flow direction generally toward the west (Brice 2016a).

In 2017, 10 monitoring wells were sampled for GRO, DRO, RRO, petroleum-related VOCs (including BTEX), and PAH at KGF Pad 14-6: MW-7, MW-8, MW-9, MW-17, MW-20, MW-22, MW-24, MW-26, MW-29, and MW-36. The 2017 groundwater monitoring results indicated exceedances of ADEC Table C cleanup levels for the following analytes: DRO, RRO, 1,2,4-trimethylbenzene, benzene, ethylbenzene, naphthalene, and 1-methylnaphthalene. Five wells were observed to have inner diameters of 1.5 inches or less and could not be sampled with a 1.5-inch HydraSleeve: MW-3R, MW-11R, MW-16, MW-17, and MW-26 (refer to Table 6-7 for well diameters). Samples from these wells were collected using a peristaltic pump at reduced flow rate, typically under 200 milliliters (mL) per minute (mL/min). Air bubbles could not be excluded from all 40-mL vials for the VOC samples collected from KGF Pad 14-6, which may be due to carbonate salts reacting with the hydrochloric acid preservative. Product was detected in three wells at the time of gauging, which were not sampled: MW-23, MW-33, and MW-41. LNAPL-absorbent socks were either placed or flipped; no used socks were removed. Eight surface water samples were collected from KGF Pad 14-6 and analyzed for BTEX and PAH. All analytes were non-detect, except toluene, which was detected at concentrations below the surface water quality standard of 10 micrograms per liter (µg/L) for TAH. Calculated values for TAH and TAqH in all surface water samples were below water quality standards

(ADEC 2018c). Well MW-12 was scheduled to be decommissioned in 2017 but could not be accessed by the drilling unit due to its location in the wetlands and unstable vegetative matting (Brice 2019b).

6.1.3 KGF Pad 14-6 2019 Monitoring Well Inspections and Maintenance

All KGF Pad 14-6 monitoring wells will be inspected, and the condition of the wells will be documented in the field logbook including any present condition that may require maintenance. Table 6-1 includes a well maintenance summary for KGF Pad 14-6.

Table 6-1: KGF Pad 14-6 Well Maintenance Summary

Well ID[1]	2017 Observations					Well Diameter[2]	Notes
	Condition	Heaving Noted	LNAPL	LNAPL-Absorbent Sock	Depth to Water (feet btoc)		
MW-1	HVE (2” well diameter)						
MW-2	HVE (2” well diameter)						
MW-3	HVE (2” well diameter)						
MW-4	Good				6.50	4”	
MW-5	Fair	X			6.75	2”	Monument cannot be locked.
MW-6	Good				5.15	2”	
MW-7	Fair	X			5.74	2”	Data logger in well.
MW-8	Fair	X			4.88	2”	
MW-9	Good				4.88	2”	
MW-10R	Good				4.14	1”	Resurvey (vertical datum incompatible).
MW-11	Good				2.09	-	Resurvey (cannot find that survey data exist for this well).
MW-12	Location in wetland area prevents drill rig access. To be decommissioned during winter months. (1” well diameter)						
MW-13	HVE (4” well diameter)						
MW-14	HVE (4” well diameter)						
MW-15	HVE (4” well diameter)						
MW-16	HVE (4” well diameter)						
MW-17	Poor	X			7.43	2”	PVC casing cut 1.32’ to allow monument to be closed and locked. Severe heaving.
MW-18	HVE (4” well diameter)						
MW-20	Good				7.06	4”	
MW-21	HVE (4” well diameter)						
MW-22	Fair	X			7.03	4”	
MW-23	Fair	X	X	X	-	4”	PVC casing cut 0.25’ to allow monument to be closed and locked.
MW-24	Fair	X			7.01	4”	PVC cut 0.53’ to allow monument to be closed and locked.

Table 6 1: KGF Pad 14-6 Well Maintenance Summary (continued)

Well ID[1]	2017 Observations					Well Diameter[2]	Notes
	Condition	Heaving Noted	LNAPL	LNAPL-Absorbent Sock	Depth to Water (feet btoc)		
MW-25	Good				4.00	1"	Resurvey (vertical datum incompatible)
MW-26	Fair				5.50	1.25" steel	
MW-27	Good				6.62	4"	
MW-28	Good				6.72	4"	
MW-29	Good				4.95	4"	
MW-30	Under 8" of gravel. To be decommissioned.						
MW-31	Fair	X			5.24	4"	No cover. PVC cut down 0.22'.
MW-33	Good		X	X	-	4"	
MW-34	Good				2.77	4"	Resurvey (vertical datum incompatible).
MW-35	Good				3.98	4"	Resurvey (vertical datum incompatible).
MW-36	Good				3.91	4"	
MW-37	Good				4.37	4"	
MW-38	Good				4.03	2"	
MW-39	Good				4.50	4"	Resurvey (vertical datum incompatible).
MW-40	Good				4.02	2"	
MW-41	Good		X	X	-	1"	

Notes:
For definitions, see the Acronyms and Abbreviations section.
- Unknown or not determined
1 **Bold** indicates that the well is a proposed water table modeling well.
2 All wells Schedule 40 PVC unless otherwise indicated.
3 Shaded rows indicate wells to be decommissioned or inaccessible due to incorporation into HVE system.

6.1.4 KGF Pad 14-6 2019 Groundwater Monitoring Activities

KGF Pad 14-6 groundwater wells are monitored on a biennial and a 4-year schedule. All viable wells are gauged during each sampling event. Additionally, eight surface water samples are collected biennially from historical locations (Figure 7). The planned field activities for the 2019 groundwater monitoring at KGF Pad 14-6 are summarized below:

- Gauge groundwater levels in all monitoring wells within a 2-hour period to determine groundwater elevations and flow direction.
- MW-23, MW-33, and MW-41: Remove LNAPL and install or replace LNAPL-absorbent socks. If LNAPL is not present, sample wells for GRO, DRO, RRO, petroleum-related VOCs (including BTEX), and PAH. Monitoring wells MW-33 and MW-41 are 1 inch in diameter and require special-ordered sorbent socks or sampling equipment.
- Sample surface water at the same eight locations for BTEX and PAH to calculate TAH and TAqH and verify contamination is not migrating off-pad and/or to the surface water.
- MW-7, MW-8, MW-9, MW-17, MW-20, MW-22, MW-24, MW-26, MW-29, and MW-36: Sample for DRO, RRO, 1,2,4-trimethylbenzene, benzene, ethylbenzene, naphthalene, and 1-methylnaphthalene.

- MW-4, MW-6, MW-10R, MW-11, MW-25, MW-28, MW-35, MW-37, and MW-40: Sample for GRO, DRO, RRO, petroleum-related VOCs (including BTEX), and PAH at a frequency of every 4 years. These wells are scheduled to be sampled in 2019.
- MW-12: Decommission during winter months when the drilling unit will be able to access the well over the frozen wetland surface and when the borehole may be more reliably sealed.
- MW-30: Decommission. This well is no longer part of the sampling program, retained only for biennial gauging; however, this well is buried under 8 inches of gravel, resulting in a significant effort to locate, uncover, gauge, and regrade with each biennial event. Surrounding wells MW-6, MW-17, and MW-31 can be used to adequately assess groundwater flow in the area.
- MW-10R, MW-11, MW-25, MW-26, MW-33, MW-34, MW-35, MW-38, MW-39, MW-40, and MW-41: Resurvey these wells during winter months when the surveyor may safely access these wells.

Table 6-2 identifies the KGF Pad 14-6 wells and sample analyses. Monitoring well and surface water sample locations are presented on Figure 7.

Table 6-2: KGF Pad 14-6 Summary of Monitoring Wells and 2019 Analyses

Well ID	Gauge	ANALYSES / METHOD									
		AK101	AK102	AK103	SW8260C				SW8270D SIM		
		GRO	DRO	RRO	Benzene	Ethylbenzene	1,2,4-trimethylbenzene	VOCs[1]	1-methylnaphthalene	Naphthalene	PAH
MW-4	X	X	X	X				X			X
MW-5	X										
MW-6	X	X	X	X				X			X
MW-7	X		X	X	X	X	X		X	X	
MW-8	X		X	X	X	X	X		X	X	
MW-9	X		X	X	X	X	X		X	X	
MW-10R	X	X	X	X				X			X
MW-11	X	X	X	X				X			X
MW-17	X		X	X	X	X	X		X	X	
MW-20	X		X	X	X	X	X		X	X	
MW-22	X		X	X	X	X	X		X	X	
MW-23	X	X	X	X				X			X
MW-24	X		X	X	X	X	X		X	X	
MW-25	X	X	X	X				X			X
MW-26	X		X	X	X	X	X		X	X	
MW-27	X										
MW-28	X	X	X	X				X			X
MW-29	X		X	X	X	X	X		X	X	
MW-31	X										
MW-33	X	X	X	X				X			X

Table 6 2: KGF Pad 14-6 Summary of Monitoring Wells and 2019 Analyses (continued)

Well ID	Gauge	ANALYSES / METHOD									
		AK101	AK102	AK103	SW8260C				SW8270D SIM		
		GRO	DRO	RRO	Benzene	Ethylbenzene	1,2,4-trimethylbenzene	VOCs[1]	1-methylnaphthalene	Naphthalene	PAH
MW-34	X										
MW-35	X	X	X	X				X			X
MW-36	X		X	X	X	X	X		X	X	
MW-37	X	X	X	X				X			X
MW-38	X										
MW-39	X										
MW-40	X	X	X	X				X			X
MW-41	X	X	X	X				X			X
Surface Water (x8)	-							BTEX			X

Notes:
For definitions, see the Acronyms and Abbreviations section.
Yellow highlight indicates that LNAPL was observed in the well in 2017. Samples will be collected if no LNAPL is observed during 2019 activities.
- Not applicable
1 Petroleum-related VOCs include BTEX, butylbenzene, isopropylbenzene, naphthalene, and trimethylbenzene.

6.2 KGF Pad 34-31

KGF Pad 34-31 is located in the western section of the KGF and approximately 1 mile northwest of KGF Pad 14-6 (Figure 4). The KGF Pad 34-31 property lies within Kenai Peninsula Borough Tax Parcels 05529054 and 05529014. The pad at KGF Pad 34-31 was constructed in the late 1950s, and six production wells were drilled between 1959 and 1994. Supporting natural gas recovery and processing infrastructure, offices, and maintenance facilities were constructed on the pad. Infrastructure on the pad includes several gas wells, former reserve pits, drum storage areas, wastewater buildings, a water injection building, a meter building, a generator building, a compressor building, offices, and workshops (SLR 2014b).

6.2.1 KGF Pad 34-31 Geology and Hydrogeology

Soils beneath KGF Pad 34-31 are interbedded, poorly sorted, medium-coarse-grained sands and gravelly sands with occasional layers of finer sands. Near the former reserve pit, lenses of silt and silty sand were observed at 5 to 10 feet bgs. Off the pad, organic soils including vegetation, peat, and organic silt are present to approximately 6 feet bgs, and are underlain by poorly sorted, fine to coarse-grained sands and gravelly sands (SLR 2014b).

In 2017, groundwater elevations ranged between 43.56 and 51.54 feet (NAVD88) (39.57 and 47.55 feet above lmsl). Groundwater flow at KGF Pad 34-31 has historically been observed to flow to the west-northwest during summer/fall sampling events (SLR 2014b). Estimated groundwater flow direction was generally consistent with historical observations (west) in 2017 (Brice 2019b).

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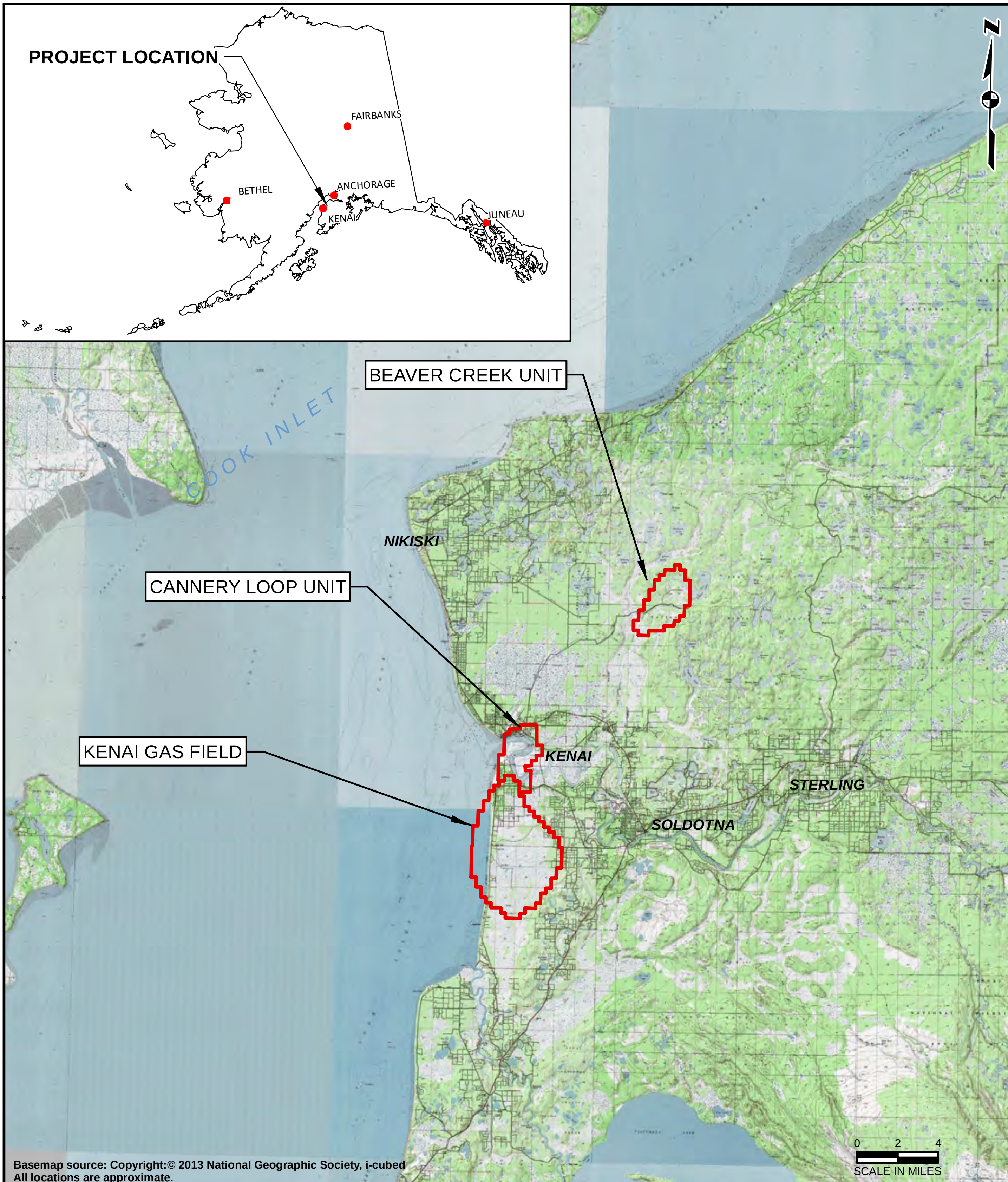
APPENDIX A:
FIGURES



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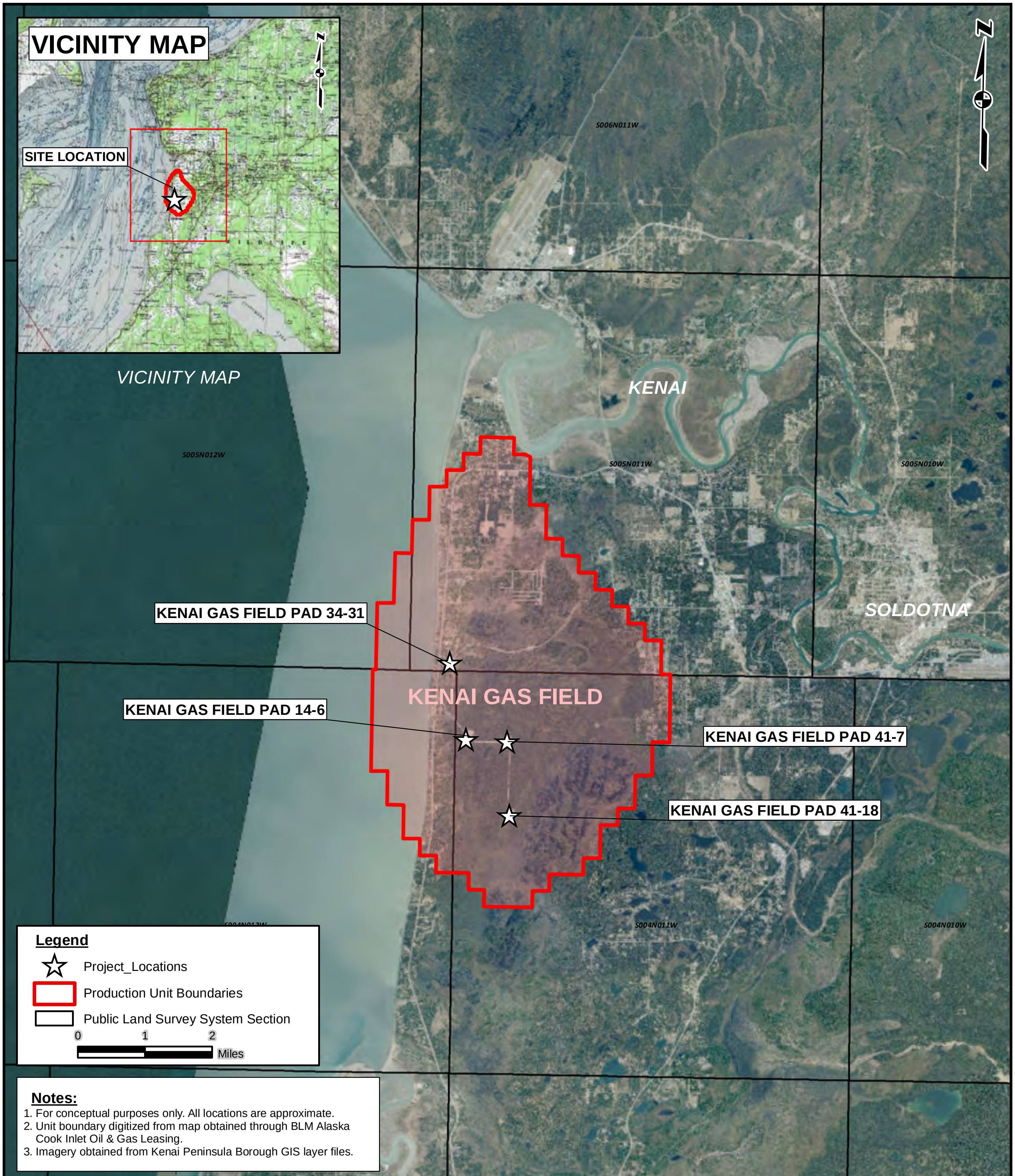
Brice ANC 8(a)
Environmental Services Corporation
3800 Centerpoint Dr. Ste.400
Anchorage, AK 99503

2019 GROUNDWATER MONITORING PROGRAM WORK PLAN
BEAVER CREEK UNIT PAD 4, CANNERY LOOP UNIT PAD 3,
KENAI GAS FIELD
KENAI PENINSULA, ALASKA

STATE AND SITE VICINITY

DATE: 5/15/2019
PROJECT No.: HG0001
DRAWN: AFS

FIGURE: 1



Notes:
1. For conceptual purposes only. All locations are approximate.
2. Unit boundary digitized from map obtained through BLM Alaska Cook Inlet Oil & Gas Leasing.
3. Imagery obtained from Kenai Peninsula Borough GIS layer files.

Brice
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2019 GROUNDWATER MONITORING PROGRAM WORK PLAN
BEAVER CREEK UNIT PAD 4, CANNERY LOOP UNIT PAD 3,
KENAI GAS FIELD
KENAI PENINSULA, ALASKA

KENAI GAS FIELD SITE MAP

DATE: 5/15/2019
PROJECT No.: HG0001
DRAWN: AFS

FIGURE: 4

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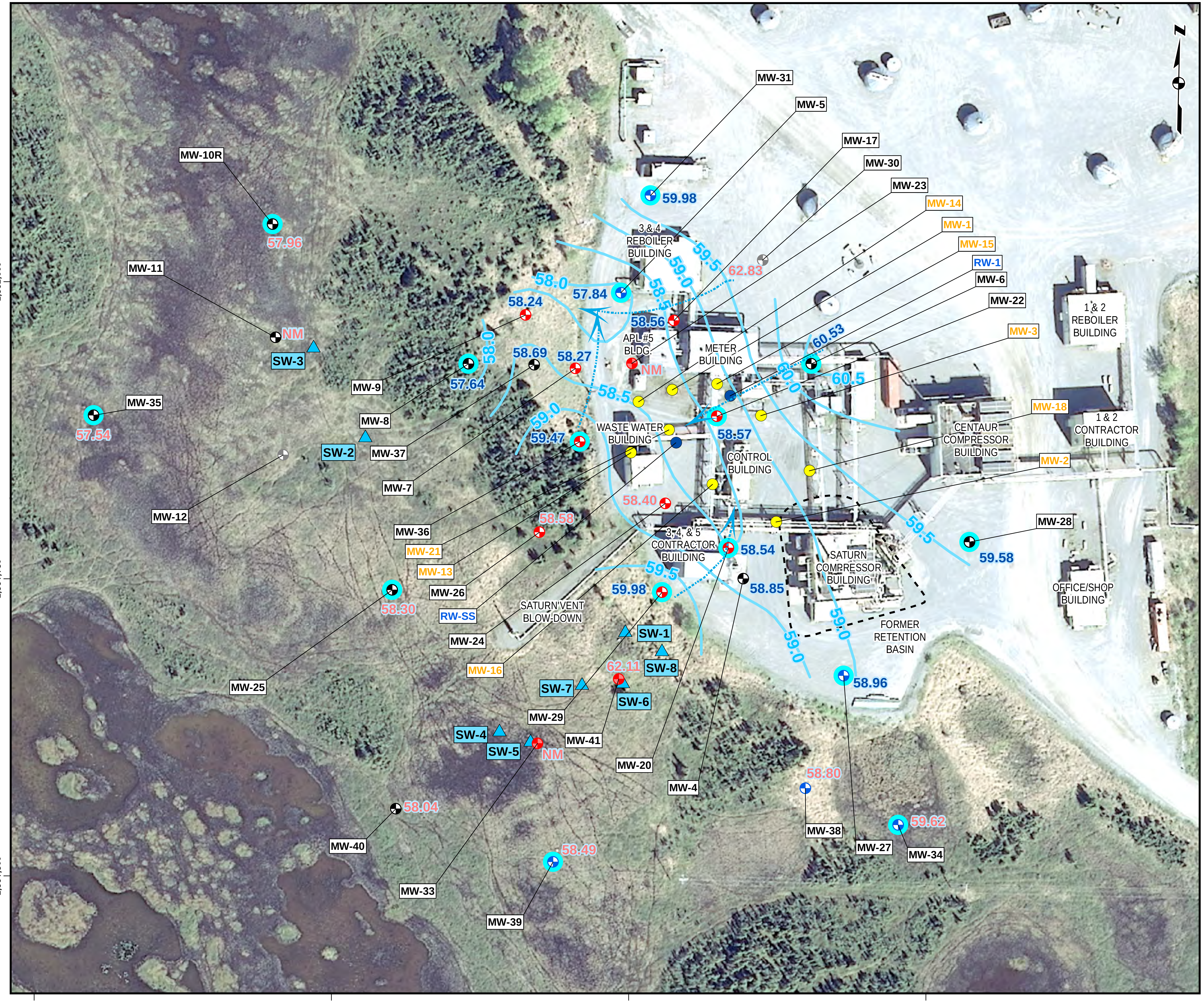

2019 GROUNDWATER MONITORING PROGRAM WORK PLAN
BEAVER CREEK UNIT PAD 4, CANNERY LOOP UNIT PAD 3, KENAI GAS FIELD

KENAI PENINSULA, ALASKA

KENAI GAS FIELD PAD 14-6

MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

- 64.5 — Groundwater Contour with Elevation (feet above lmsl)
- Approximate Groundwater Flow Direction
- XX.XX — Groundwater Elevation (feet above lmsl)
- XX.XX — Groundwater Elevation (feet above lmsl) Not Used for Contouring
- Former Retention Basin (Approximate Boundary)

Monitoring Well Locations

- High Vacuum Extraction (Inaccessible)
- Deep Aquifer Well (not in Contaminated Sites Sampling Program)
- To be Decommissioned
- Gauge Only
- Gauge and Sample 2019
- Gauge and Sample 2019; Exceedance in 2017
- Gauge and Sample 2019; LNAPL Present in 2017
- Cyan Halo Around Any Symbol Indicates Proposed Water Table Modeling Well
- Surface Water Sample Location

Notes:

1. For conceptual purposes only. Site feature locations are approximate.
2. Imagery acquired from Quantum Spatial Inc. Imagery was taken on May 31, 2017.
3. Groundwater elevations are posted in feet above local mean sea level (lmsl). This elevation was calculated by subtracting 3.99 from surveyed NAVD88 elevations (at the suggestion of McLane).
4. Groundwater contours were generated with Surfer 13 software, using kriging, then edited by hand to reflect hydrological interpretation.
5. Water levels at monitoring wells MW-10R, MW-24, MW-25, MW-26, MW-30, MW-34, MW-38, MW-39, and MW-40 were omitted from modeling due to uncertainty in casing elevation resulting from the age of the previous survey data. MW-11 water level was not measured due to inaccessibility (NM = not measured).
6. Water levels at monitoring wells MW-23 and MW-33 were omitted from modeling due to the presence of LNAPL during gauging.
7. Cyan circles around the well symbol indicate that a well is proposed to be a dedicated water table modeling well for assessing groundwater flow direction. Only these wells will be used for generating water table contours and assessing groundwater flow direction at each future monitoring event.

ALASKA STATE PLANE COORDINATE SYSTEM ZONE 4

U.S. SURVEY FEET

HORIZONTAL DATUM: NAD83 (2011)   VERTICAL DATUM: local mean sea level

80 40 0 80 160

Scale in Feet

Anchorage Office
3800 Centerpoint Drive, Suite 400
Anchorage, AK 99503
907.275.2896 (Office and Fax)

Brice Environmental Services Corporation

PROJECT No.: HG0001	DATE: 6/10/2019	FIGURE: 7
P.M.: JA	DRAWN: AFS	

Document Path: \\brice.local\dfs\GEOSPATIAL_PROJECTS\BESI\HILCORP\2019_GWM_GIS\1_MXD\WORK_PLAN\KGF_CLU_BCU\F7_2019_KGF_14-6.mxd

APPENDIX B:
STANDARD OPERATING PROCEDURES

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STANDARD OPERATING PROCEDURE

BE-SOP-01

Logbook Documentation and Field Notes

1.0 SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) describes the criteria for the content and format of field logbooks and has been generated in accordance with the Alaska Department of Environmental Conservation (ADEC) *Field Sampling Guidance* (ADEC 2017). This SOP should be used to direct field personnel in the requirements for recording information in logbooks to ensure that field activities are properly documented.

Adequate documentation is necessary to describe the work performed. Attention to detail is vital as field logbooks are useful in the reporting process as well as in administrative and judicial proceedings. As a result, it is important that documentation be factual, complete, accurate, consistent, and clear.

2.0 PERSONNEL RESPONSIBILITIES

All site personnel who make logbook entries are responsible for maintaining the required documentation. The Field Team Lead will inform personnel as to who will be responsible for field notebook and form entries, care, and maintenance.

3.0 FIELD NOTEBOOK PROCEDURE

Field logbooks are bound, sequentially paginated, weatherproof notebooks used to record daily field activities. All notes will be entered in permanent ink.

3.1 FRONT COVER

The front cover of each logbook must include the following information:

- Project name and Site ID
- Project Month(s) and Year
- Name(s) of field logbook author(s)

3.2 PROJECT CONTACT INFORMATION

Include project contact information on the inside front cover or first page of the logbook. Contact information includes names and phone numbers of subcontractors, project assistants, field team members, and emergency numbers from the Accident Prevention Plan and/or Site-Specific Health and Safety Plan.

3.3 DAILY ENTRIES

Logbook entries should abide by the following guidelines:

- Pages should never be removed from the logbook.
- All information must be printed legibly and in permanent ink.
- Entries should be written using objective and factual language and should be made in chronological order.
- Entries will be made on subsequent lines such that no blank lines exist on any page.
- If any space remains on the bottom of the last page of field entries at the conclusion of the day's entries, a diagonal line will be drawn and signed to obscure any additional entries on that page.
- If corrections are necessary, a single line may be drawn through the original entry. The corrected information may then be added and should be initialized and dated.

Each logbook page should include the following:

- Job name or number, date, and personnel at the top of each page.
- Date and signature at the bottom of each page, with a line through any remaining blank lines.

The daily standard logbook entries will include the following:

- Project name/ Site ID / Client
- Date and time of each activity (including work start/stop times); time will be based on the 24-hour clock (i.e., 2100 instead of 9 pm)
- Location of activity
- Weather conditions and changing weather that may impact site conditions
- Pertinent observations and comments
- Level of Personal Protective Equipment
- Full names of onsite personnel and affiliations (including all visitors)
- Daily objectives
- Field measurements and calibrations
- Deviations from the project-specific Work Plan
- Photograph logs
- Site sketches with reference to north direction (with approximate scale or "not to scale" noted), sample and field screening locations and depths (with results), and on-site groundwater flow direction (if known)
- Daily calibrations, equipment checks, and maintenance
- Survey and/or location of any sampling points, including swing-tie measurements
- For each sample record: date, time, sampler(s), sample ID, media, sample location, sample depth taken below ground surface (bgs), container(s), preservatives, QC (dup/MS/MSD), analysis, MeOH lot number, tare weight
- Sample shipments (when, what, destination)
- Waste tracking (when, how much, destination)
- References to relevant data sheets and documentation preserved outside of the logbook such as groundwater sampling data sheets, soil boring logs, etc. Do not duplicate information from the referenced sheets in the logbook.

- Decontamination times and methods
- Daily summary of activities (i.e. number of samples collected)

Correct erroneous field record or log book entries with a single line through the error. Do not erase incorrect information. Date and initial revised entries.

3.4 FIELD DATA SHEETS

All other supportive unbound data documentation that is a part of the field records should be maintained as part of the field forms. These records should be recorded in weatherproof ink and on weatherproof paper as necessary. Once back into the office, the unbound records will be scanned to create an electronic record to ensure document preservation.

3.5 ELECTRONIC DATA SHEETS

Electronic data documents include photographs, GPS and survey data, etc. All electronic data that are part of the field records will be downloaded to a designated location and maintained for project use. Take care when downloading, storing, and managing data. Naming conventions (according to the project-specific Work Plan) should be used to indicate the project, date, and other relevant information to ensure accurate use.

3.6 DOCUMENT CONTROL

At the conclusion of a task or project, all field documentation should be submitted to the Project Administrator for record retention. All original documents should be kept in the project file.

4.0 REFERENCES

ADEC. 2017 (August). *Field Sampling Guidance*.

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STANDARD OPERATING PROCEDURE

BE-SOP-02

Sample Chain-of-Custody

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes the guidelines for sample handling and custody and has been generated in accordance with the Alaska Department of Environmental Conservation (ADEC) *Field Sampling Guidance* (August 2017). This SOP will be used to direct field personnel in the techniques and requirements for maintaining the sample chain of custody (COC).

The purpose of the COC is to demonstrate accountability and document sample integrity from the time of sample collection until sample analysis by the laboratory.

2.0 COC ELEMENTS

The elements of a COC for sample collection include the following:

- Sample labeling
- Laboratory receipt forms
- Field custody form (COC form)
- Custody seals on each cooler
- Inter-laboratory transfer documentation, if applicable

3.0 SAMPLE HANDLING PROCEDURE

The following sections describe sample COC documentation, field custody procedures, COC record, sample packaging, custody seals, transfer of custody, and laboratory custody procedures.

3.1 SAMPLE COC DOCUMENTATION

Sample identification documents will be carefully prepared so that sample identification and COC are maintained. Sample identification documents include the field logbook, sample labels, custody seals, and COC records.

A sample is in custody if it meets one of the following conditions:

- In an authorized person's physical possession,
- in an authorized person's view after being in possession,
- was in an authorized person's possession then secured (locked up), or
- kept in a secured area that is restricted to authorized personnel.

3.2 FIELD CUSTODY PROCEDURES

The following procedures will be used by field personnel:

- The sample collector will be personally responsible for the care and custody of samples collected until they are properly transferred to another company representative or relinquished to the laboratory.
- The sample collector will record sample data (time of collection, sample number, analytical requirements, and matrix) in the field logbook and/or appropriate field form.
- Sample labels shall be completed for each sample, using weatherproof ink.

3.3 CHAIN-OF-CUSTODY RECORD

The COC record will be fully completed prior to the shipment of samples. Information to be included on a COC form includes the following:

- COC Number
- Project number
- Contractor name
- Sampler name or initials
- Sample identification
- Location ID
- Sample date and time (in 24-hour format)
- Laboratory analysis methods required for each sample jar
- Volume submitted
- Preservatives added to each sample jar
- Sample matrix (soil, water, or other)
- Quantity of containers per sample
- Turn-around-time
- Instructions or notes regarding the samples in the “Notes” section of the custody record

3.4 SAMPLE PACKAGING

Samples will be labeled and packaged according to the *Labeling, Packaging, and Shipping Samples* SOP (BE-SOP-03). The COC record will accompany all sample shipments. Two COC records should be prepared for each shipment. One COC record will be placed in a re-sealable plastic bag, the bag sealed shut to prevent water intrusion from the moisture in the cooler, and the bag taped to the inside lid of the cooler. The duplicate copy of the COC record will be retained by the sampler and distributed as necessary to the sample coordinators. Airway bills will also be retained with the COC record as documentation of transport.

3.5 CUSTODY SEALS

Custody seals are preprinted, adhesive-backed seals with security slots designed to break if the seals are disturbed. Seals will be signed and dated at the time of use. Sample shipping containers will be sealed in as many places as necessary to ensure that the container cannot be opened without tearing the custody seals. Typically, one custody seal will be placed along the front corner of the cooler, and one along the opposite back corner of the cooler. Clear tape will be placed over the seals to ensure that seals are not accidentally broken during shipment. If the custody seal was broken at some point during transport, the reason for breaking the seal, condition of the container contents, the cooler temperature, and anything added to or removed from the container must be documented on the COC form. The container must then be sealed with a new custody seal.

If a sampler hand-transports the samples to the laboratory without sample shipment, custody seals are not required.

3.6 TRANSFER OF CUSTODY

When transferring the possession of samples from the field sampler to a transporter or to the laboratory, the sampler will sign, date, and note the time as “relinquished by” on the COC record. The receiver will also sign, date, and note the time as “received by” on the COC record. However, when samples are transported by a common commercial carrier such as Alaska Airlines or Federal Express, the carrier will not sign the COC record.

3.7 LABORATORY CUSTODY PROCEDURES

A designated sample custodian will accept custody of the shipped samples and verify that the sample identification number matches the COC record. Pertinent information about shipment, pickup, and courier will be entered in the “Remarks” section. The custodian then will enter sample identification number data into a bound logbook that is arranged by a project code and station number.

4.0 REFERENCES

ADEC. 2017 (August). *Field Sampling Guidance*.

ATTACHMENTS

Attachment A Chain of Custody Form

Chain-of-Custody Report

Collection Organization: **Chain-of-Custody:** **Cooler ID:** **NPDL Number:**

Project Number: **Laboratory:** **Bill To:** **Report To:**

COC Sample ID	Loc ID	Collection Date	Collection Time	Sampler	Quantity	Container Type	Volume	Preservative	Matrix	Analyses Requested Group	QC	TAT	Notes:

Special Instructions:

Relinquish By: Relinquish By: Temperature Blank:

Signature/Printed Name Date/Time Signature/Printed Name Date/Time

Received By: Received By: Cooler Temperature:

Signature/Printed Name Date/Time Signature/Printed Name Date/Time

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STANDARD OPERATING PROCEDURE

BE-SOP-03

Labeling, Packaging, and Shipping Samples

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) will be used to direct field personnel in the techniques and requirements of labeling samples for identification, packaging samples for safe transport, and shipping samples from the field to laboratory for analysis.

Proper labeling, packaging, transport, and shipping are necessary to maintain an accurate record to track the samples, as well as safe methods of packing and transporting samples.

2.0 MATERIALS

The term “environmental sample” refers to any sample that has less than reportable quantities of any hazardous constituents according to Department of Transportation (DOT) 49 CFR - Section 172. Equipment required for labeling, packaging, and shipping environmental samples include:

- Weatherproof labels for sample containers
- Coolers
- Contractor-grade plastic bags
- Sorbent pads
- Plastic zip-top bags, quart and gallon
- Clear tape
- Strapping tape
- Bubble wrap and/or foam inserts
- Gel ice packs
- Cooler labels: “keep cool/refrigerate/do not freeze,” “this end up,” “fragile,” address, dangerous goods, excepted quantities, Saturday delivery (as necessary), etc.

3.0 PROCEDURES

This section describes the procedures for labeling, packaging, and shipping samples that have been collected.

3.1 LABELING

Samples will be labeled using nomenclature defined in the project-specific Work Plan. All sample labels will be weatherproof and contain the following information:

- Project number
- Sampler name or initials
- Sample identification
- Sample date and time (in 24-hour format)
- Laboratory analysis methods required for sample jar
- Volume submitted
- Preservatives added to sample jar
- Sample matrix (soil, water, or other)
- Turn-around-time

Adhesive sample labels will be placed directly on the sample containers. If the labels do not adequately adhere due to moisture, secure the label by placing clear packaging tape over the label. Sample containers that are weighed by the laboratory prior to use **should not** have any additional labels placed on the container as it affects the weight. For those containers, use the label that is already provided on the jar. Only one label should be placed on each sample container.

3.2 PACKAGING

When packing sample containers for shipment, the steps below must be followed.

1. Choose a cooler with structural integrity that will withstand shipment. Secure and tape the drain plug with duct tape.
2. Be sure that the caps on all containers are tight and will not leak. Make sure not to over-tighten and/or break the cap.
3. Ensure that the sample labels are intact, fully completed with the correct information, and that identification exactly matches the chain-of-custody record.
4. Use sufficient ice in packaging to ensure that samples are received by the laboratory at the proper temperature of 0-6°C.
5. Wrap and package containers sufficiently to prevent cross contamination and ensure that containers remain intact during shipment.

3.2.1 Gel Ice

When packing samples with gel ice packs, the following steps must be taken:

1. Place a layer of frozen gel ice packs, along the bottom of the cooler. Cover the ice packs with a layer of bubble wrap and then place a sorbent pad over the bubble wrap.
2. Place sample containers in bubble wrap, bubble bags, in their original boxes, or in re-sealable bags with sorbent pads, depending on the type of container.
3. Place the containers into the cooler with caps up.
4. Fill excess space between sample containers with additional bubble wrap or gel ice,
5. Place another layer of bubble wrap along the top of the cooler, and if possible, place a layer of gel ice packs along the top of the cooler.
6. Fill remaining headspace with additional packing material.

Note that partially melted or soft gel ice packs should not be used to pack coolers for transport. A minimum of 8 frozen gel ice packs should be used to maintain sample temperature during transit for 24 hours.

After gel ice has been placed in the cooler, the following steps must be taken:

1. Ensure that a temperature blank is included in each cooler. The temperature blank should be placed at the same level and next to the samples, preferably in the center of the cooler.
2. Place the completed Chain-of-Custody record for the laboratory into a plastic zip-top bag, tape the bag to the inner side of the cooler's lid, and then close the cooler.
3. Conduct a "shake test" by gently shaking the cooler to determine if the containers are shifting in the cooler. If so, add additional packing material until there are no sounds of shifting when shaken.
4. Wrap strapping tape around each end of the cooler two times to secure the lid. Place completed custody seals on the front and back of the cooler so that the cooler cannot be opened without breaking the seals. Place clear tape over custody seals.
5. Attach an address label containing the name and address of the shipper to the top of the cooler. Attach other markings such as "Refrigerate" or "Keep Cool," "Do Not Freeze," and "Fragile." For samples with liquid (including preserved soil samples), place "up arrow" stickers on opposite sides of the cooler pointing in the same direction as the containers containing liquids.

3.3 SAMPLE SHIPPING

Environmental samples are shipped as non-hazardous materials unless the samples meet the established DOT criteria for a "hazardous material" or the International Air Transport Association (IATA)/International Civil Aviation Organization (ICAO) air definition of "dangerous goods." If the samples meet criteria for hazardous materials or dangerous goods, then DOT and IATA/ICAO regulations must be followed, which includes having qualified personnel send shipments.

Samples shipped as "Dangerous Goods in Excepted Quantities" must have the appropriate labelling and be declared as dangerous goods to the shipping carrier. However, no dangerous goods "candy-striped" form must be filled out and no Notification to Caption (NOTOC) is required (IATA 2016).

3.3.1 Soil Sample Shipments

Soil samples preserved with methanol, and any excess methanol vials, must be shipped as "Dangerous Goods in Excepted Quantities" per the IATA regulations. The volume for excepted quantities of methanol is 30 mL per container and 500 mL per cooler. The hazard class number is 3, flammable liquid, UN 1230. Sample jars with methanol in excess of 30 mL and coolers with methanol in excess of 500 mL require shipment as "Dangerous Goods" and require the completion of a "candy-striped" form.

3.3.2 Water Sample Shipments

Water samples preserved with hydrochloric acid or other insignificant amounts of preservative are not shipped as dangerous goods. However, pre-preserved sample containers with preservative and no water added must be shipped as "Dangerous Goods in Excepted Quantities" per IATA regulations. The volume for excepted quantities of hydrochloric acid or nitric acid is 30 mL per container and 500 mL per cooler respectively. The hazard class number is 8, corrosive. Sample jars with hydrochloric acid or nitric acid in excess of 30 mL and coolers with hydrochloric acid or nitric acid in excess of 500 mL require shipment as "Dangerous Goods" and require the completion of a "candy-striped" form.

Upon shipping samples, notify the laboratory contact that samples have been shipped and provide the airway bill number.

4.0 REFERENCES

IATA. (2016). *Dangerous Goods Regulations (DGR) Limited/Excepted Quantities Labels.*

STANDARD OPERATING PROCEDURE

BE-SOP-04

Quality Control Samples

1.0 INTRODUCTION

The purpose of this Standard Operating Procedure (SOP) is to direct field personnel in the requirements necessary for collecting field quality control (QC) samples from certain matrixes. Field QC samples are collected to ensure the reliability and validity of field and laboratory data.

2.0 PROCEDURE

The following sections describe different QC sample types that will be required in project-specific Work Plans.

2.1 FIELD DUPLICATE

A field duplicate is collected to evaluate whether sample matrix inhomogeneity, contaminant distribution, or sample collection methods affect analytical precision. The field sampler will ensure the primary and duplicate samples are effectively identical. The duplicate sample is collected from the same location, at the same time, with the same techniques, and the same matrix.

Frequency of field duplicates, at a minimum, are 1 blind field duplicate per day and 1 blind field duplicate per 10 samples for each analytical method and matrix for offsite laboratory analysis of all field samples.

Field duplicates are submitted as blind samples with a unique sample number and collection time to the approved laboratory for analysis (Alaska Department of Environmental Conservation [ADEC] 2017).

2.2 MATRIX SPIKE AND MATRIX SPIKE DUPLICATE (MS/MSD)

An MS/MSD sample is collected to evaluate the precision and accuracy of laboratory procedures in the project sample matrix. The MS/MSD compound will be added at the laboratory. This sample is collected at the same time as the primary sample using the same procedure, equipment, and type of container. The MS/MSD sample should be labeled the same as the primary sample with the same sample identification and time and denoted on the chain-of-custody (CoC) form to ensure that the project MS/MSD pair is used in the laboratory report. The frequency of MS/MSD samples collected, at a minimum, is one for each analytical batch. The required frequency of the MS/MSD sample collected is specified in the Quality Assurance Protection Plan (QAPP) and/or project-specific Work Plan, and the evaluation process is specified in the QAPP.

2.3 TEMPERATURE BLANK

A temperature blank will be included in each sample cooler. A temperature blank is measured by the laboratory to verify and document that the cooler temperature is received between 0-6 degrees Celsius (°C). Temperature blanks consist of plastic bottles filled with water, which the laboratory typically prepares. Once shipments are received by the laboratory, the temperature will be recorded on the CoC to document preservation requirements were met.

2.4 TRIP BLANKS

Trip blanks will accompany samples to be analyzed for volatile analysis including GRO, BTEX, and VOCs. Trip blanks are prepared by the laboratory and are used to establish that the sample has not been contaminated by external sources during the transport of sample bottles to and from the field. Trip blanks are samples of reagent-grade water, properly preserved in a controlled environment prior to field mobilization by the laboratory. Trip blanks will be kept with the sample containers throughout the sampling process and returned to the laboratory with the other samples. One trip blank will accompany each cooler containing VOC and/or GRO samples, or as specified in the QAPP or project-specific Work Plan. The evaluation process is specified in the QAPP. All trip blanks will be labeled and included on the CoC. Trip blank sample times will generally be recorded as 0800 on the CoC.

2.5 EQUIPMENT BLANKS

Equipment blanks may be used to evaluate the effectiveness of a decontamination procedure. The equipment rinsate blank is collected by pouring deionized water onto or into the sampling equipment after the equipment has been decontaminated, and then collecting the rinsate water for analysis of an analytical suite identical to that performed for the associated sample(s). The required collection frequency of equipment rinsate blanks is specified in the QAPP and/or project-specific Work Plan, and the evaluation process is specified in the QAPP. Decontamination procedures are to be performed according to the *Equipment Decontamination* SOP (BE-SOP-14).

3.0 REFERENCES

ADEC. 2017 (August). *Field Sampling Guidance*.

STANDARD OPERATING PROCEDURE

BE-SOP-09

Groundwater Sample Collection

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) provides field operation and protocols applicable to the collection of representative water samples from groundwater monitoring wells and temporary well points. This SOP is consistent with the Alaska Department of Environmental Conservation (ADEC) *Field Sampling Guidance* (ADEC 2017) and with the U.S. Environmental Protection Agency (EPA) *Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells* (EPA 2017). For specific sampling locations and analytes, refer to the project-specific Work Plan.

2.0 EQUIPMENT AND SUPPLIES

Groundwater sampling equipment will include, but is not limited to the following:

- Appropriate level of Personal Protective Equipment (PPE)
- Camera
- Logbook, weatherproof pen, sharpie, etc.
- RAE Systems MiniRAE photoionization detector (PID) (or similar)
- *Well Purge and Sampling Forms*
- Sample labels
- Sampling containers and packing materials
- Tape measure
- Oil/water interface probe
- Submersible (stainless steel centrifugal Proactive Monsoon pump with low-flow controller, or equivalent), bladder pump, or peristaltic pump
- Disposable Teflon bailers and twine
- 5-gallon bucket
- Graduated cylinder or beaker
- Yellow Springs Instruments (YSI) water-quality meter (or similar)
- Potable water and/or deionized water
- Tubing (Teflon and/or silicone)
- Liquinox, Alconox, or equivalent

3.0 PROCEDURES

The following sections describe methods of recording field observations, calibrating field instruments, conducting air monitoring, checking for free product, measuring water levels, and purging and groundwater sampling using a submersible or peristaltic pump.

3.1 RECORDING FIELD OBSERVATIONS

The *Well Purge and Sampling Form* is intended to capture the information routinely collected during the sampling process for established monitoring wells. The field logbook is intended to record all equipment calibration checks, the wells sampled, sampling start and end times, or any other pertinent information not captured on the Groundwater Sampling Data Form. All data collected from temporary well points will be recorded in the field logbook.

3.2 FIELD INSTRUMENT CALIBRATION

Field instruments will be calibrated in accordance with the manufacturer's recommended procedures and frequency for each instrument. Operation and maintenance manuals will be available in the field for reference. Calibrations will be evaluated at the beginning of each day prior to use. If any reading is outside ± 5% from the expected calibration standard, the equipment will be re-calibrated. If after calibration, the instrument remains outside the expected calibration standard, the instrument will be removed from project use and replaced as soon as practicable.

3.3 AIR MONITORING

Air monitoring will be conducted to determine the presence of volatile organic compounds (VOCs) using a PID (MiniRAE 2000 or similar). PID readings will be monitored until stable and then recorded in the field logbook. Procedures in the Site-specific Safety and Health Plan (SSHP) will be followed if organic vapors are detected above concentrations listed in the air monitoring section of the SSHP. PID readings will be collected in the following situations:

- To monitor ambient conditions prior to removing the well plug and opening the well monument (either above ground or flush mount type).
- To monitor the ambient conditions in the breathing zone when opening the well or removing the well plug.
- To monitor the headspace immediately after removing the well plug.
- To monitor the breathing zone after the well plug has been removed.

3.4 FREE PRODUCT AND WATER LEVEL MEASUREMENT

The depth to free product (if present) and the depth to groundwater will be measured with an oil/water interface probe. Interface probes provide distinct responses when immersed in nonconductive product or conductive water. The type and order of measurement activities include determining the reference elevation, taking product and water level measurements, removing free product, and measuring the total casing depth as described below:

- Reference Elevation:
    - Pre-existing reference elevation (mark or notch on the casing)
    - No pre-existing reference elevation (typically for new wells)
        - Place a mark on the outside of the top north side of the well casing with indelible ink
- Product and Water Level Measurements (measured to the nearest 0.01 foot):
    - Measure the depth to free product (if present)

- Measure the thickness of free product (if present)
- Measure the depth to groundwater
- Free Product Removal (if present and more than 0.1 feet thick):
  - Remove free product with a bailer or peristaltic pump
  - Determine the volume of product removed
  - Dispose in accordance with the project-specific Work Plan
- Total Well Depth (after well construction is complete or after sampling in established wells):
  - Measure the depth to the bottom of the well casing
  - Compare to constructed well depth to determine the thickness of silt

3.5 PURGING

Purging is the process by which stagnant water is removed from the location prior to sampling and replaced with groundwater from the adjacent formation. This allows for a representative sample to be collected from the actual aquifer condition.

Purging will be conducted in accordance with EPA and ADEC low-flow guidelines (EPA 2017, ADEC 2017). Monitoring wells will be purged, at minimum, the equivalent of three times the well volume, or until three of the four stabilization parameters (specific conductance, oxidation reduction potential [ORP], pH, and dissolved oxygen [DO]) have stabilized. If using temperature for stabilization, four of the five stabilization parameters should be stabilized. The volume of water purged from each well will be calculated based on the length of the water column and well casing diameter. The formula to calculate the water volume to be purged is as follows:

Purge volume = 3 well casing volumes = (total depth of casing (ft) – depth to groundwater) * gallons per linear foot * 3. Refer to the *Well Purge and Sampling Form* for the various gallons per linear foot based on the casing diameter of the well.

$$V = {}^*0.041D^2(d_2-d_1)$$

V= Volume in gallons

D = Inside diameter of well casing in inches

d_2 = Total depth of well in feet

d_1 = Depth to water surface in feet

*0.041 is based on a 1-inch diameter well.

Criteria for low-flow sampling are described below:

- Drawdown during purging will be less than 0.3 feet, if possible.
- Flow rates typically range from 0.1 to 1.0 liters per minute (0.03 to 0.3 gallons per minute), but higher rates are consistent with low-flow guidelines as long as the drawdown requirement is met.
- Water quality parameters will be measured and recorded as tabulated in Table 1.

If a well is purged dry, it will be allowed to recharge for 24 hours, or to 80% of its pre-purge volume. Without further purging, the well will be sampled. Water quality parameter stabilization is reached when three consecutive changes between successive readings at approximately 3-5 minute intervals are within the criteria in Table 1. Turbidity readings consistently below 10 nephelometric turbidity units (NTU) are considered stabilized.

Table 1 Stability Criteria for Low-Flow Purging

Parameter[1]	Units	Recording Precision	Stability Criterion	Typical Value Range for Stability Criterion
pH	-	0.01	±0.1	5 to 8
Temperature	°C	0.01	±0.2°C or ±3%	0.1 to 15
Conductivity	µS/cm	1	±3%	80 to 1,000
Turbidity	NTU	0.1	± 10% or ± 1 NTU (whichever is greater)	0.3 to > 900
ORP	mV	1	± 10	-120 to 350
DO	mg/L	0.1	± 10% or 0.2 mg/L (whichever is greater)	0 to 12

Note: Stability criteria from ADEC *Field Sampling Guidance* (ADEC 2017).
[1] Only three parameters are required to stabilize, four when using temperature.

3.6 GROUNDWATER SAMPLE COLLECTION USING A SUBMERSIBLE OR PERISTALTIC PUMP

Low-flow sampling will use a submersible, bladder, or peristaltic pump. For collection of VOCs, a peristaltic pump should not be used unless approval from ADEC is obtained prior to sample collection. If a peristaltic pump is used for sample collection, VOC samples should be collected using Hydrasleeve groundwater samplers. Wells that contain free product are not typically sampled. Samples should be collected using the following steps:

- Line the ground with plastic sheeting to provide a clean work environment
- Lower the pump (submersible or bladder) or tubing (peristaltic) to the target depth below the static water level. Record the depth of the pump on the *Well Purge and Sampling Form*. For wells screened across the groundwater interface, a pump intake of 1.0 to 2.0 feet below the static water level is typically used. For wells with submerged screens, set the pump intake at the middle of the screened interval.
- Begin purging water into a container (i.e. 5-gallon bucket). Adjust the flow rate so that drawdown does not exceed 0.3 feet (where possible). The flow rate can be slowly increased or decreased as needed.
- After the turbidity of the water decreases, connect the flow-through cell to begin measuring stabilization parameters. Continue to purge until stabilization criteria are met (Table 1) or three well casing volumes are removed. Remove the supply line from the flow-through cell and place such that the purge water is captured in a container.
- Don new nitrile gloves prior to handling sample bottles.
- Collect samples in the appropriate containers (with preservatives if required by the analytical methods):

   - If ADEC approves the use of a peristaltic pump for the collection of VOC samples, the following procedure will be followed: 40 mL vials for VOCs/GRO must be filled slowly to prevent splashing and entrainment of air bubbles. Reduce the pumping rate, if necessary, to control the flow rate. Care should be taken to avoid touching the mouth of the discharge line, the top of the sample bottle, the inside of the cap, or the Teflon septum. A septum that falls out of the cap onto the ground cannot be used. The vial will be filled completely so that a convex meniscus forms. The cap will then be secured and the bottle inverted, tapped firmly, and checked for the presence of air bubbles. Analytical results will be compromised if air is trapped in the sample container.
      - If a Hydrasleeve groundwater sampler is used in conjunction with a peristaltic pump for VOC/GRO sample collection, the *Hydrasleeve Standard Operating Procedure: Sampling Ground Water with a HydraSleeve* will be followed.
- Remove the submersible pump or the tubing.
- Measure the total depth of the well as described in Section 3.4
- Record measurements on *Groundwater Purge and Sampling Form*.

Waste will be handled in accordance with the project-specific Work Plan.

4.0 POTENTIAL INTERFERENCES

Two potential interferences associated with groundwater sampling are cross-contamination and a lack of sample representation due to improper well purging or stabilization. To prevent cross-contamination between wells, dedicated tubing will be placed in each well and all non-disposable equipment that may directly or indirectly come in contact with samples, will be decontaminated prior to use at a different location. The *Equipment Decontamination* SOP (BE-SOP-14) outlines the decontamination procedure. To ensure that representative conditions within the aquifer are captured during sample collection, purging will be conducted at a rate that produces minimal drawdown until three well casings have been collected or until water quality parameters have stabilized as described in Section 3.5.

5.0 SAMPLE HANDLING, PRESERVATION, AND STORAGE

The following procedure will be followed for sample handling, preservation, and storage:

1. Transfer the sample into a labeled container
2. Preserve the sample or use pre-preserved sample bottles (if required by analytical method)
3. Cap the container and place into a cooler to maintain 4 ± 2°C (if required by analytical method)
4. Record all pertinent data in the site logbook and/or on the field data sheet
5. Complete the chain of custody form
6. Attach the custody seals to the cooler prior to shipment

Refer to the *Labeling, Packaging, and Shipping* SOP (BE-SOP-03) for procedures on labeling, packaging, and shipping samples.

6.0 DATA AND RECORD MANAGEMENT

The chain of custody form is signed over to the laboratory. A copy is kept with the sampling records. Refer to *Sample Chain of Custody* SOP (BE-SOP-02) for procedures on sample chain-of-custody.

7.0 QUALITY CONTROL AND QUALITY ASSURANCE

All field Quality Control (QC) sample requirements in the project-specific Work Plan must be followed. These may include trip blanks, equipment blanks, field duplicates, and the collection of additional sample volumes for the laboratory's quality control (matrix spike and matrix spike duplicates). The frequency of QC samples will be outlined in the project-specific Work Plan. Refer to the *Quality Control* SOP (BE-SOP-04) for procedures on quality control samples.

8.0 DECONTAMINATION

Refer to the *Equipment Decontamination* SOP (BE-SOP-14) for procedures on decontamination.

9.0 REFERENCES

ADEC. 2017 (August). Field Sampling Guidance.

EPA. 2017 (September). Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells. EQASOP-GW4. R. Reinhart and J. Smaldone (authors).

ATTACHMENTS

Attachment A   Well Purge and Sampling Form

WELL PURGE AND SAMPLING FORM

SITE ID: **WELL ID:** **SHEET** **OF**

PROJECT NAME		WELL CONDITION	
CLIENT		DAMAGE PRESENT	
SITE		HEIGHT OF STICKUP (ags)	
SAMPLER(S)		TOTAL DEPTH (btoc)	
WEATHER / TEMPERATURE		DEPTH TO WATER (btoc)	
		HEIGHT OF WATER COLUMN (feet)	
DATE		1 WELL VOLUME (gal)	
START TIME		3 WELL VOLUMES (gal)	
END TIME		DROWNED SCREEN?	

DIAMETER	O.D. (inch)	I.D. (inch)	VOLUME (gal/LF)
1" Sch40	1.315	1.049	0.05
2" Sch40	2.375	2.067	0.17
3" Sch40	3.5	3.068	0.38
4" Sch40	4.5	4.026	0.66
6" Sch40	6.625	6.065	1.50
8" Sch40	8.625	7.981	2.60
2" Sch80	2.375	1.939	0.15
4" Sch80	4.5	3.826	0.60

SAMPLING DATA

SAMPLE TYPE (GW, PRODUCT, OTHER):

COLLECTION METHOD (PUMP TYPE, OTHER):

IF PRODUCT IS PRESENT	DESCRIPTION:
DEPTH TO PRODUCT (btoc)	THICKNESS OF PRODUCT (feet)

SAMPLING APPARATUS:

TUBING SIZE / TYPE:

EQUIPMENT DECON PROCEDURE:

FLOW RATE (mL/min)	SAMPLE PORT DEPTH (btoc)
Highest purge rate with stable drawdown	
Highest rate during sampling	

1 L = 0.264 gal 1 gal = 3.785 L

Historical Parameter Observations

	pH	Cond. (µS/cm)	ORP (mV)	D.O. (mg/L)	Turbidity (NTU)	Drawdown (btoc)
Last Observed						
Historical Average						
Highest Observed						
Lowest Observed						

FIELD WATER QUALITY PARAMETERS

Time	Cumulative Purged Volume (gal)	Water Level (btoc)	Drawdown (btoc)	Temperature (°F or °C)	pH	Conductivity (µS/cm)	ORP (mV)	D.O. (mg/L)	Turbidity (NTU)	Color	Odor
				± 3% (min ± 0.2 °C)	0.1	± 3%	± 10mV	± 10%	± 10% or ±1 NTU		

FINAL PURGE DATA: START TIME: END TIME: CUMULATIVE VOLUME: MAX FLOWRATE WITH STABLE DRAW DOWN:

ANALYTICAL SAMPLE INFORMATION

SAMPLE DESCRIPTION:
(color, product, odor, etc.)

Sample ID	Date	Time	Matrix	Containers	QC	Analysis / Preservative									Remarks

SAMPLING NOTES:

BOTTLE LOT NUMBER(S):

EQUIPMENT SERIAL NUMBERS: **YSI** **Turbidimeter** **Other**

FIELD WATER QUALITY PARAMETERS

SHEET   OF

Time	Cumulative Purged Volume (gal)	Water Level (btoc)	Drawdown (btoc)	Temperature (°F or °C)	pH	Conductivity (µS/cm)	ORP (mV)	D.O. (mg/L)	Turbidity (NTU)	Color	Odor
				± 3% (min ± 0.2 °C)	0.1	± 3%	± 10mV	± 10%	± 10% or ±1 NTU		

STANDARD OPERATING PROCEDURE

BE-SOP-10

Surface Water Sampling

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes the guidelines and procedures of collecting surface water samples. The SOP for the collection and analysis of sediment samples is found separately in the *Sediment Sampling* SOP (BE-SOP-07). The methodologies discussed in this procedures are applicable for liquid samples, both aqueous and non-aqueous, from streams, rivers, lakes ponds, lagoons, and surface impoundments. These procedures are applicable for samples collected at the surface.

Collection and handling of surface water samples will be executed or directly supervised by a qualified environmental professional, as defined in 18 AAC 75.333(b).

2.0 MATERIALS AND EQUIPMENT

Collection of surface water includes, but is not limited to:

- Logbook
- Waterproof pen
- Field datasheets (e.g., sample description sheets, etc.)
- Tape measure
- Survey stakes, flags (white), or buoy and anchors
- Dip sampler
- Sampling jars
- Kemmerer bottle
- Preservatives
- Safety equipment
- Decontamination fluids and equipment
- Bottle labels
- Coolers and ice

Refer to Attachment 1, *Water Sampling Checklist* for a more detailed equipment list.

2.1 REAGENTS

Reagents are used for the preservation of surface water samples including hydrochloric acid (HCL), nitric acid (HNO3), sodium hydroxide (NaOH), sodium sulfite, and ascorbic acid. HCL, HNO3, and NaOH are used to preserve surface water samples collected in the field for volatile organic compound (VOC), metals, and cyanide analyses respectively. It is not expected that surface water samples will contain free (residual) chlorine unless they are treated effluent samples or are collected near the outfall of a treated water effluent. If chlorine is suspected, the water will be tested for free chlorine using chlorine test strips according to manufacturer directions. If samples are collected for VOC, semi-volatile organic compound (SVOC), or cyanide analyses, samples that test positive for residual chlorine will require treatment with a reducing agent before sample preservation. Ascorbic acid is used as a reducing agent for samples collected for VOC and cyanide analyses, and sodium sulfite is used as a reducing agent for samples collected for SVOC analysis. Samples collected for oil analysis may sometimes be preserved with HCL or sulfuric acid to prevent degradation by microbial action.

Reagents used for decontamination of sampling equipment is found in the *Equipment Decontamination* SOP (BE-SOP-14). Non-aqueous samples are typically not preserved due to the uncertain nature of the matrix, which may evolve harmful gases upon addition of acid or base to the sample.

3.0 PROCEDURE

3.1 SAMPLING PREPARATION

Prior to conducting sampling activities, a sampling preparation meeting will be held by the team to discuss the proposed sampling strategy for the project-specific Work Plan. Site history, contaminant concerns, sampling methodology, individual responsibilities, sample shipment or delivery, health and safety issues, and lines of communication anticipated during the sampling event will be discussed.

3.2 SURFACE WATER COLLECTION

Surface water samples will be collected using hand tools. Typically, surface samples are collected from just below the water surface. Sampling locations greater than 1 foot below water surface is considered outside the scope of the procedure.

Samples will be collected at a frequency specified in the project-specific Work Plan. Samples will be collected as follows:

- Don new PPE (gloves, etc.) before starting sample collection.
- Verify that all needed equipment is readily available and that the sample containers are new and have been properly prepared.
- Label container and sample-specific data sheet, if applicable.
- Using decontaminated or disposable sampling equipment, collect water from the sampling location by slightly submerging the sample container just below the water surface at a slight angle. If preservatives are in the sampling container, use a sampling container with no preservatives to collect the surface water and fill any pre-preserved sampling containers.
- Allow the container to fill with minimal agitation of the water. Be sure to avoid overfilling of the sample container by leaving a slight amount of headspace in the sample jar.
- Place the cap on the sample jar and tighten.
- Wipe the outside surface of the sample jar using a paper towel
- Place samples upright in a pre-chilled cooler immediately after sample collection.
- Record in the field logbook the sample identification, the sample collection location (sketch), the depth from which the sample was collected, and if a duplicate sample was collected, any discoloration or odor, and other pertinent details.

- Decontaminate any reusable sampling equipment or discard used disposable sampling equipment between samples. The *Equipment Decontamination* SOP (BE-SOP-14) will be followed for decontamination procedures.

3.3 HANDLING AND PRESERVATION

Samples will be collected using the appropriate unused sample containers (with preservative, if required by the analytical method) provided by the analytical laboratory. Sample containers will be labeled with the sample identification number, date and time of collection, sampler initials, and analysis requested. Samples will maintained at 4 degrees Celsius (°C) ± 2 °C while in storage (if required by the analytical method). Samples will then be packaged and transported to the subcontracted laboratory for analysis.

3.4 QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance and quality control samples will be collected in accordance with the *Quality Control Samples* SOP (BE-SOP-04) and the project-specific Work Plan.

ATTACHMENTS

Attachment 1 Water Sampling Checklist

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STANDARD OPERATING PROCEDURE

BE-SOP-14

Equipment Decontamination

1.0 INTRODUCTION

The purpose of this Standard Operating Procedure (SOP) is to describe the procedures for decontamination of reusable equipment.

2.0 MATERIALS

Materials used for decontamination, include but are not limited to the following:

- Modified Level D Personal Protective Equipment (PPE)
- Brushes, typically stiff bristle
- 5-gallon buckets
- Liquinox, Alconox, or equivalent
- Spray or rinse bottles, or pump sprayer
- Paper towels
- Potable water
- Distilled or deionized water
- Other hand tools for gross contamination (shovels, brooms, etc.)
- Garbage bags
- Plastic sheeting
- Approved waste containers

3.0 PROCEDURE

Decontamination of reusable sampling equipment will be conducted between sample locations and at the end of each work day. Drilling and excavation equipment will be decontaminated prior to beginning site activities, at the termination of site activities, and, if used for sampling, prior to each sampling event. Materials removed during decontamination will be collected and managed with similar waste streams and the project-specific Work Plan.

3.1 DECONTAMINATION AREA

Identify a localized decontamination area for drill rigs and other sampling equipment. Select the decontamination area so that decontamination fluids and soil wastes can be managed in a controlled area with minimal risk to the surrounding environment. The decontamination area should be large enough to allow temporary storage of cleaned equipment and materials before use, as well as to stage drums of decontamination investigation-derived waste (IDW). In the case of large decontamination areas (for example, for hollow-stem auger decontamination), line each area with a heavy-gauge plastic sheeting and include a collection system designed to capture potential decontamination IDW.

Decontamination areas should be laid out in such a manner as to prevent overspray while performing equipment and personnel decontamination.

Smaller decontamination tasks, such as surface water and sediment equipment decontamination, may take place at the sampling locations. In this case, all required decontamination supplies and equipment must be mobilized to the site and smaller decontamination areas for personnel and portable equipment will be provided as necessary. These locations will include basins or tubs to capture decontamination IDW, which will be transferred to larger containers as necessary.

3.2 PERSONNEL AND PERSONAL PROTECTIVE EQUIPMENT (PPE)

Personnel decontamination involves removal of gross contamination first. Contaminated solids such as mud should be scraped and wiped from boots, and gloves should be removed by rolling off the hands, starting at the cuff, in such a way that the gloves are turned inside out during removal. If necessary, a clean pair of gloves should be worn to complete the boot cleaning process. Boots can be cleaned while being worn or following removal. Any remaining contamination should be removed using soapy water, brushes or other similar means such as a pressure washer, if available. Once all debris is removed, rinse with clean water. If boots are not laden with gross solid materials, a brush can simply be used to knock off or remove any residual solid materials. If the boots have contacted liquid-phase contaminants, it is important that the contaminants be removed using soapy water and a brush followed by a clean water rinse. If the contaminants have adsorbed into the boots, the boots must be disposed of and a replacement pair obtained before conducting any further field activities.

Following removal and cleaning of reusable PPE, field personnel should wash their hands or any exposed body parts which may have been in contact with the associated contaminated substances.

3.3 SAMPLING EQUIPMENT DECONTAMINATION

All reusable sampling equipment will be cleaned prior to use. The following procedure will be used by field personnel:

1. Remove as much gross contamination as possible off equipment at the sampling site.
2. If heavy petroleum residuals are encountered during sampling, an appropriate solvent such as methanol should be used to remove any petroleum residues from sampling equipment.
3. Wash water-resistant equipment thoroughly and vigorously with potable water containing laboratory-grade detergent such as Liquinox, Alconox, or equivalent. Use a bristle brush or similar utensil to remove any remaining residual contamination.
4. Rinse equipment thoroughly with potable water (1st rinse).
5. Rinse equipment thoroughly with distilled or deionized water (2nd rinse).
6. For sensitive field instruments, rinse equipment with distilled, deionized, or reagent grade water (3rd rinse).
7. Air dry at a location where dust or other fugitive contaminants may not contact the sample equipment. Alternatively, wet equipment may be dried with a clean, disposable paper towel to assist the drying process. All equipment should be dry before reuse.

Clean, dry sampling equipment will be stored within a protective medium (plastic bag, etc.) or staged in a clean area for future use.

Cleaning and decontamination of the equipment will be accomplished in stages in such a way that the contamination does not discharge into the environment. Cleaning and decontamination wastes must be properly contained and disposed of in accordance with applicable state and federal regulations.

Disposable sampling equipment should be used whenever possible (e.g. drum thieves, bailers, spoons, etc.) to minimize the need to decontaminate these items.

3.4 HEAVY EQUIPMENT DECONTAMINATION

Gross decontamination of equipment will be performed prior to transporting or walking equipment within different areas of or between contaminated areas or exclusion zones. Gross decontamination will focus on minimizing the spread of contaminated media as a result of equipment movement or transport. This decontamination process will use dry methods (brooms, wipes, shovels, etc.) within the exclusion zone to remove large, easily dislodged deposits of soil and other contaminated media prior to exiting the exclusion zone. The Site Manager may increase the level of gross decontamination based upon the effectiveness of using dry decontamination.

Final decontamination will occur when equipment is no longer needed on site within a decontamination pad to allow for the collection of decontamination materials, sludge, and water. When equipment is to be removed permanently, it will be decontaminated using brushes and/or a pressure washer with a detergent wash followed by a fresh water rinse. All areas of the equipment which were potentially contaminated will be decontaminated as described in Section 3.3.

3.5 DRY DECONTAMINATION

Where dry decontamination is required, the following steps will be followed at the sampling site by field personnel:

1. Remove as much debris or contamination as possible using a dry brush or paper towel.
2. Spray equipment with a detergent/water mix.
3. Wipe down with a clean, dry paper towel.
4. Spray equipment with potable water.
5. Wipe down with a clean, dry paper towel.
6. Spray equipment with deionized or distilled water.
7. Wipe down with a clean, dry paper towel.

Dispose of all paper towels with other IDW and disposable sampling supplies.

4.0 INTERFERENCES

Improper decontamination may cause cross-contamination across sites, analytical samples, or field screening instruments. To prevent cross-contamination of analytical samples, sampling equipment will be disposed of after one use, or decontaminated after, or prior to each use. Additionally, laboratory-certified clean glassware will only be used for storing analytical samples.

5.0 QUALITY CONTROL

Quality Control (QC) samples may be collected to verify the decontamination process is effective. QC samples include the equipment rinsate blank and the equipment wipe sample which are described in detail in the *Quality Control* SOP (BE-SOP-04).

STANDARD OPERATING PROCEDURE

BE-SOP-20

Water Quality Measurements

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes the methods for calibrating, maintaining, and operating the YSI 556 Multi-Parameter Water Quality Meter. The YSI 556 simultaneously measures numerous water quality parameters including temperature, conductivity, salinity, dissolved oxygen (DO), pH, and oxidation Reduction Potential (ORP). This SOP also describes the guidelines for operating the Hach Portable Turbidity Meter.

2.0 EQUIPMENT

Water quality meters and instruments vary. Below is a list of the typical instruments used in the field:

- YSI 556 MDS Multi-Parameter Datalogger
- YSI 6-Series Sonde Field Cable
- Flow-Thru Cell
- Hach 2100P Portable Turbidity Meter
- Discharge hoses and fittings to attach sample tubing to the flow-thru cell
- Distilled water
- Calibration solution for YSI (pH 4, 7, and 10, ORP, and conductance)

3.0 PROCEDURES

It is important to note that different instrument models exist and therefore the appropriate operation and procedure manual should be referenced prior to use.

3.1 CALIBRATION FOR YSI 556

Calibration of instruments for all field parameters needs to be conducted daily. Calibration readings should be documented in the field logbook. If a field instrument will not calibrate, perform troubleshooting as described in the manufacturer's manual. If the issue cannot be resolved, use a backup instrument. If that is not an option, contact the PM on whether data collection will continue or any other corrective actions should be taken. Flag any data recorded from a meter with suspected calibration problems on the field forms. Calibrate the YSI for pH, conductivity, ORP, and DO. Store the YSI probe according to manufacturer instructions in pH 4.0 solution. Do not store the probe in deionized water as it can damage the probe sensors.

3.1.1 pH Calibration

Always calibrate pH with a 3-point calibration method. The 3-point calibration method accounts for the full pH range and assures maximum accuracy when the pH of the media to be monitored cannot be anticipated.

3.2 YSI MULTI-PARAMETER WATER QUALITY METER

3.2.1 Groundwater parameters

Follow the general procedure for collecting water quality parameters using a flow-thru cell:

- Secure the multi-meter probe to the flow-thru cell. Connect a short discharge tube to the effluent connector at the top of the flow-thru cell and run the other end of the discharge tube into a purge water container.
- Place the tube from the pump directly into the 5-gallon purge water bucket and start to purge approximately half a minute or until the purge water begins to visually clear up. The intent is to limit any initially high turbidity water from filling and settling in the flow-thru cell.
- Once visually clear, turn off the pump briefly and secure the tube from the pump to the influent connector at the bottom of the flow-thru cell. Turn on the pump again and allow the flow-thru cell to completely fill with water.
- Begin low flow purging of the well at a flow rate of approximately 1 liter (0.25 gallons) every 3-5 minutes.
- Routinely measure and record dissolved oxygen (DO), oxidation reduction potential (ORP), conductivity, pH, turbidity, temperature, and the depth to groundwater every 3-5 minutes until stabilized. A minimum of three recordings will be monitored and recorded.
- Continue to monitor until stabilized or until three well casing volumes have been purged. Use the following stabilization parameters:
  - ± 3% for temperature (minimum of ± 0.2 °C),
  - ± 0.1 for pH,
  - ± 3% for conductivity,
  - ± 10 mv for ORP,
  - ± 10% or 0.2 mg/L (whichever is greater) for DO, and
  - ± 10% or ±1 NTU (whichever is greater) for turbidity.

  Note: Low flow purging and sampling are particularly useful for wells that purge dry or take one hour or longer to recover. If a well is low yield and purged dry, do not collect a sample until it has recharged to approximately 80% of its pre-purge volume, when practical.

- When parameters have stabilized, record final measurements and collect samples as per the project-specific Work Plan.

3.2.2 Surface Water Parameters

When collecting surface water samples, a flow-thru cell is not required. Instead connect the probe sensor guard to the connector nut to protect the sensors. Place the probe in the water being careful not to disturb the bottom. Let sit for about 5 – 10 minutes and then take parameters.

3.3 HACH 2100P PORTABLE TURBIDITY METER

The Hach Model 2100P Portable Turbidimeter measures turbidity from 0.01 to 1000 NTU in automatic range mode with automatic decimal point placement. Use the following generic procedure for turbidity measurements:

- Collect a representative sample in a clean container. Fill a sample cell to the line (about 15 mL), taking care to handle the sample cell by the top. Cap the cell.
- Wipe the cell with a soft cloth to remove water spots and fingerprints.
- Apply a thin film of silicone oil. Wipe with a soft cloth to obtain an even film over the entire surface.
- Turn the instrument on and place on a flat sturdy surface.
- Insert the sample cell in the instrument compartment so the diamond or orientation mark aligns with the raised orientation mark in front of the cell compartment.
- Press READ and the result will show in units of NTU.

Refer to the user's manual provided with rental equipment for calibration and maintenance documentation.

4.0 REFERENCES

Hach Company. 2008 (April). *Hach Portable Turbidity Meter Model 2100P Instrument and Procedure Manual*

YSI Environmental. 2009 (August). *YSI 556 Multi Probe System Operations Manual*

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STANDARD OPERATING PROCEDURE

BE-SOP-21

Groundwater and LNAPL Measurements

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes the procedures and equipment that should be used to determine water levels, depth to floating product, or total depth in a groundwater monitoring well. Groundwater measurements can be used for several purposes during field activities, including but not limited to, measuring changes in time, and determining the magnitude of horizontal and vertical hydraulic gradients in an aquifer system.

A water level meter will typically be used to measure depth to groundwater (DTW) and total depth (TD) in wells. If Light Non-Aqueous Phase Liquid (LNAPL) is present in the well, an oil-water interface probe will be used.

2.0 EQUIPMENT

Groundwater and LNAPL measurement equipment will include:

- Water Level meter with audible alarm and a cable marked in 0.01 foot increments
- Oil-water interface meter (only if LNAPL layer is suspected)
- Decontamination equipment

2.1 DEPTH TO WATER/DEPTH TO LNAPL MEASUREMENT

If the well is sealed with an airtight cap, allow time for the pressure to equilibrate after the cap is removed before measuring water levels. Take measurements until consecutive readings are within 0.01 foot.

Before taking measurements, ensure a reference point is established. For easy reference, mark the point with a permanent surveyor's reference mark, such as a small notch cut into the casing or a permanent ink mark at the top of the casing. If no reference mark is present, mark the north side of the monitoring well casing.

Measure DTW and DTP as follows:

- With the water level indicator switched on, slowly lower the water level meter or oil-water indicator probe down the monitoring well until the probe contacts the groundwater or LNAPL surface, as indicated by the audible alarm. Do not let the probe tip and tape free-fall down the well. Always hold onto the meter's reel handle.
- Raise the probe out of the water or LNAPL until the audible alarm stops. Continue raising and lowering the probe until a precise level is determined within 0.01 foot.

- If LNAPL is present in the well, measure and record the depth from the TOC reference point to the top surface of the LNAPL layer (that is, DTP). The oil-water indicator probe alarm will sound a continuous tone when LNAPL is detected.
- Continue to lower the probe until the meter indicates the presence of groundwater. The alarm will typically emit a beep when water is detected. Measure the first static groundwater level and record the measurement (DTW) from the reference point to the top of the static groundwater level.
- Record the measurements in the field logbook or on the *Well Purge and Sampling Form*.

2.2 TOTAL DEPTH MEASUREMENT

Use the following procedures to measure the TD of a groundwater monitoring well:

- Slowly lower the water level meter until the cable goes slack. Do not let the probe tip and tape free-fall down the well. Always hold onto the meter's reel handle.
- Gently raise and lower the water level meter probe to tap the bottom of the well.
- Record the reading on the cable at the established reference point to the nearest 0.01 foot.

If there is an offset between the bottom of the probe and the water level sensor, adjust the measurement accordingly. Record the TD measurement in the field logbook or on the *Well Purge and Sampling Form*. Decontaminate water level meters and interface probes between monitoring wells in accordance with BE-SOP-14 to avoid cross-contamination.

STANDARD OPERATING PROCEDURE

BE-SOP-22

Monitoring Well Installation, Development, and Decommissioning

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) is to be used as reference to describe the process for constructing, installing, and developing groundwater monitoring wells provided by a drilling subcontractor via drill-rig operation. This SOP provides a standard set of procedures applicable under typical site conditions and may vary based on actual site conditions and/or equipment characteristics. This SOP is consistent with *Monitoring Well Guidance* issued by the Alaska Department of Environmental Conservation (ADEC 2013). Specific monitoring well design and installation procedures depend on project objectives and subsurface conditions, and should be discussed in the project-specific Work Plan (WP).

Monitoring wells can be installed as long-term monitoring wells, which can be repeatedly sampled over several years, or as temporary well points, which allow for a one-time groundwater sampling event. Following development, purging, and sampling - a temporary well point is usually removed and backfilled in accordance with ADEC regulations.

2.0 EQUIPMENT AND MATERIALS

The drilling subcontractor will supply all materials and equipment necessary to perform drilling activities in accordance with the Drilling and Core Logging SOP (BE-SOP-05) and will install monitoring wells in locations based on field observations, the Statement of Work (SOW), and in the project-specific WP.

Temporary well points are most commonly 1- to 2-inch diameter screened PVC or stainless steel pipe, which can be pre-packed with filter material, or used without a filter pack. Temporary well points can be installed using a direct push drill rig or by hand, if in unconsolidated material with a shallow water table.

Monitoring wells are usually installed with pre-packed screens, using a direct push drill rig or a hollow stem auger.

Equipment and materials needed for monitoring well installation include, but are not limited to, the following:

- Geoprobe® 66 series drill rig or equivalent
- Well casing and screen
- Filter pack materials
- Bentonite
- Surface seal materials (concrete)

- Potable water and/or deionized water
- Weighted tape measure

Monitoring well development equipment includes, but is not limited to the following:

- Water level meter or Oil/Water interface probe
- Surge block (with foot valve)
- Submersible pump
- Sprinkler pump (useful for removing large volumes of silt and fine sand laden water)
- Inertial pump and tubing (optional-consider for deep wells greater than 30 feet)
- Disposable polyethylene or Teflon bailers
- 5-gallon buckets
- Graduated cylinder or beaker
- YSI water-quality meter
- Hach portable turbidity meter
- Potable water and/or deionized water
- Disposable polyethylene tubing

3.0 DOCUMENTATION

Fill out the attached *Well Installation and Well Development Forms* following installation and when developing the monitoring well. All fields on the installation form must be completed for long term monitoring wells as well as temporary well points. All fields on applicable field forms will be used or an "NA" will be inserted to indicate a field that is not applicable. The field form sections are outlined below:

- Well designation;
- Date of well installation;
- Date of development;
- Static water level before and after development;
- Quantity of drilling fluid lost during drilling;
- Well volume;
- Depth from top of well casing to bottom of well;
- Screen length;
- Depth from top of well casing to top of sediment inside well, before and after development, if present;
- Physical characteristics of removed water, including changes during development in clarity, color, particulates, and odor;
- Type and size/capacity of pump and/or bailer used;
- Height of well casing above/below ground surface;
- Typical pumping rate;
- Estimate of recharge rate; and
- Quantity of water removed and time of removal.
- The *Drilling and Core Logging* SOP (BE-SOP-05) will be followed in compliance with the ASTM D2488 Unified Soil Classification standards. The *Core Log* SOP (BE-SOP-05 Attachment) field form

must be completed during installation and before leaving the site to ensure all details are captured and are complete and accurate.

- Monitoring wells will be surveyed within a horizontal accuracy of 1.0 feet and a vertical accuracy of 0.01 foot. The top of the well casing will be surveyed as well as ground surface for use as a reference point to determine water-level elevation, sampling depths, and groundwater flow direction. All survey information will be documented in the field log book.

4.0 WELL INSTALLATION PROCEDURES

This section describes drilling, borehole, casing, well screen, bentonite seal, and monitoring well completion requirements.

Prior to monitoring well installation, ADEC recommends developing a conceptual model of the site geology and hydrology. This allows for a better understanding of the distribution of aquifers and aquitards at or near the site, hydrologic boundaries, the water surface table, and other hydrogeographic properties. This is a working model to be updated as new data is obtained.

4.1 DRILLING REQUIREMENTS

Several drilling methods are available for creating a borehole for well installation. Primary methods include hollow stem, direct push, air rotary, mud rotary, and cable tool. The drilling method is chosen based on physical subsurface properties.
All drilling activities will be supervised by a qualified environmental professional. The drill rig will be decontaminated appropriately before it enters and leaves the site in accordance with the *Equipment Decontamination* SOP (BE-SOP-14). All leaks will be repaired prior to coming to the site or as soon as they are discovered at the site. The drill rig will not leak any fluids that may enter the borehole or contaminate equipment placed in the hole. The use of rags or absorbent materials to soak up leaking fluids is unacceptable. Brice, or the drilling subcontractor, will have spill response equipment on site at all times to ensure constant preparedness in the case fluids begin to drip from the rig so they do not impact the site.
Drilling mud, synthetic drilling fluids, petroleum or metal based pipe joint compounds, and other potential contaminants will not be used unless necessary. Only high yield sodium bentonite clay free of organic polymer additives will be used if drilling mud is needed to stabilize the hole.

Decontamination water must be potable and obtained from a known water source.

An “as built” drawing will be constructed for each monitoring well. Each well point will be surveyed.

4.2 BOREHOLE REQUIREMENTS

Borehole diameters should be at least three inches larger than the nominal outside diameter of the casing and well screen. If using a hollow stem auger, the inside diameter of the auger should be at least four inches larger than the nominal outside diameter of the casing and well screen, unless otherwise specified in the approved project-specific Work Plan.

The completed monitoring well must be straight and plumb to allow passage of pumps or sampling devices.

4.3 CASING REQUIREMENTS

The following lists requirements for the casings of monitoring wells:

- All casing will be new, unused, and pre-cleaned (if necessary).
- Glue or solvent will not be used to join casing; casings will be joined only with water-tight flush-joint threads or thermal welds that will not interfere with the planned use of the well.
- Pop rivets or screws should not be used on casings or other monitoring well components.
- All monitoring wells will conform to the American Society for Testing Materials (ASTM) F-480-06b. The inside diameter should be at least 1.9 inches, with the exception of well points for piezomenters and transducers. Polyvinyl chloride (PVC) is a durable monitoring well material with good chemical resistance (EPA 1991).
- All metal casing will be seamless stainless steel casing.
- The casing will be straight and plumb within the tolerance stated for the borehole.
- A notch in the top of the casing will be cut to be used as a measuring point for water levels and survey activities. Boring location will be noted based on the identification number.
- The addition of bentonite surrounding the PVC casing will be visually verified during well installation activities to ensure that bridging is not occurring during withdrawal of the drill string/equipment.

4.4 WELL SCREEN REQUIREMENTS

The following are the requirements that must be met for well screens:

- All requirements that apply to casing will also apply to well screen, except for strength requirements.
- Monitoring wells will not be screened across more than one water-bearing unit. Screens will be factory slotted or wrapped.
- Screen slots will be sized to prevent 90 percent of the filter pack from entering the well, and for wells where no filter pack is used, the screen slot size will be selected to retain 60 to 70 percent of the formation materials opposite the screen.
- The bottom of the screen is to be capped, and the cap will be joined to the screen by threads.

In most hydrogeologic settings, screen lengths should not exceed 10 feet. The use of shorter well screens may allow for contaminant detection by reducing excessive dilution.

4.5 FILTER PACK REQUIREMENTS

Surrounding the monitoring well intake with materials that are coarser, of uniform grain size, and have a higher permeability than natural formation material allows the groundwater to flow freely into the well from adjacent formation material while minimizing or eliminating the entrance of fine gained materials. Determine the appropriate filter pack (natural or artificial) application for a given well. An artificial filter pack typically meets these conditions. Deciding between natural and artificial filter pack depends on the grain size distribution of the natural formation materials in the monitored zone. Grain size is determined by conducting a sieve analysis of a soil sample for the intended screened interval. The filter pack should extend above the well screen to a length of 20 % of the well screen length, but no less than 2 feet (ASTM

D5092 2005). The thickness of the filter pack should be at least 2 inches between the borehole and the well screen, and no greater than 8 inches (EPA 1991).

4.6 SEAL REQUIREMENTS

An annular seal should be installed to restrict vertical movement of water or contaminants by sealing the well casing to the adjacent soil formation. The annular seal consists of bentonite chips from the filter pack to approximately 2 feet below the ground surface.

The bentonite seal requirements for wells installed deeper than 12 feet below ground surface, are as follows:

- The bentonite seal will consist of at least two feet of bentonite between the filter pack and the silica sand used to fill the borehole to the ground surface.
- The bentonite will be hydrated after placement.
- Only 100 % sodium bentonite will be used.

The bentonite seal will be terminated 2 feet from the ground surface. The remainder of the annulus will be backfilled using silica sand to minimize bentonite intrusion into the well monument and to promote drainage of water from inside the monument. If the monitoring well is advanced in frozen ground, the annular space between the casing and any permafrost should be sealed to minimize effects on the subsurface thermal regime and to prevent water within the well from freezing.

Seal requirements for wells with submerged screens or screened in deep confined aquifers will be described in the site-specific work plan.

4.7 SOIL BORING AND LOGGING

Soil borings will be logged at each site where monitoring wells will be installed. Refer to BE-SOP-05 for the drilling and core logging procedure.

4.8 MONITORING WELL SURFACE COMPLETION REQUIREMENTS

Surface completion is not necessary for temporary well points.

If flush-mounted completions, cut the casing approximately six inches below the ground surface and provide a water-tight casing cap to prevent surface water from entering the well. A freely draining surface monument with a locking cover should be placed over the casing. The surface monument should be placed in well-sorted sand to allow water drainage. If the well is located on a gravel pad, the top of the monument must be completed at least three inches below pad grade to protect it from snow removal equipment. The top of the casing will be at least one foot above the bottom of the surface monument. The identity of the well should be permanently marked on the monument lid and the casing cap.

For above-ground monitoring well completions, extend the well casing two or three feet above ground surface. Provide a casing cap for each well, and shield the extended casing with a steel sleeve that is placed over the casing and cap and seated in a 3-foot by 3-foot by 4-inch concrete surface pad. To allow for escape of gas, a small diameter (e.g., 1/4-inch) vent hole must be placed in the well casing, or a ventilated well cap will be used. The diameter of the sleeve should be at least six inches greater than the diameter of the casing. Install a lockable cap or lid on the guard pipe. The identity of the well should be permanently marked on the casing cap and the protective sleeve.

Well locations must be designed to ensure groundwater samples and water level measurements characterize discrete stratigraphic intervals. This is achieved by positioning the screened interval relative to the water table elevation.

Well locations and designs must prevent surface contaminants from entering the groundwater as well as leakage of groundwater or contaminants between the stratigraphic intervals in the well bore or along the well annulus. Complete wells above grade to decrease potential of surface contaminants entering the well.

Install monitoring wells where there is no chance of seasonal inundation by floodwaters, unless the wells have special watertight construction.

Long-term monitoring well development:

- A drilled, long term monitoring well is typically composed of well casing, well screen, and filter pack.
- Place the filter pack into the annulus to a minimum of two feet above the top of the screen and one foot beneath the well endcap.
- Reduce the required filter pack height to allow for annular space sealant.
- Apply bentonite chips to seal the annular space.

5.0 WELL DEVELOPMENT PROCEDURES

Monitoring wells should not be developed for at least <u>24 hours after installation.</u>

Wells can be developed using a submersible pump, peristaltic pump, and or bailer. Bailers are more commonly used in wells where there is a small volume of water.

Monitoring wells can be developed by first purging the well dry, if possible, then allowing the monitoring well to refill with formation water. If the recovery rate by the formation water is too slow, up to one well casing volume of potable water can be added to the well. The well should be surged vigorously for approximately 10 minutes using either a surge block or bailer. Add more water as necessary. Purge the well dry again to complete the development process (ADEC 2013).

A minimum of three borehole volumes (calculated from the borehole diameter and the length of screen below the water table, corrected for 30 percent porosity of the filter pack) of water and twice the volume of water added during drilling and construction will be removed.

In the event of submerged wells, the borehole volume is calculated over the interval of the filter pack (length of screen plus 2 feet of added sand above the screen).

After initial surging and pumping, groundwater parameters will be monitored for stability criteria (described below).

Groundwater parameter stability is reached when three changes between successive readings at approximately 5-minute intervals at a low-flow pumping rate (drawdown less than 0.3 feet) are less than the criteria provided in Table 1.

Table 1
Stability Criteria for Low-Flow Purging

Parameter[1]	Units	Recording Precision	Stability Criterion
pH	—	0.01	±0.1
Temperature	°C	0.01	±0.2
Conductivity	µS/cm	1	±3%
Turbidity	NTU	0.1	± 10% or ± 1 NTU (whichever is greater)
Oxidation Reduction Potential (ORP)	mV	1	±10
Dissolved Oxygen (DO)	mg/L	0.1	±10% or 0.3 mg/L (whichever is greater)

Notes:
°C = degrees Celsius
µS/cm = microSiemens per centimeter NTU
= nephelometric turbidity units mV =
millivolts mg/L=milligrams per liter
Stability criteria from ADEC *Field Sampling Guidance* (ADEC 2016).
[1] Only three parameters are required to stabilize, four when using temperature.

Low-yielding wells are exceptions to the above criteria. Such wells should be purged dry, then either be allowed to recover or be filled with potable water to the static water level for surging. Add water as needed to maintain the water level during surging. Satisfactory recovery is defined as 80 percent of the well volume. After the initial recovery period, such wells will be surged and pumped dry again to complete the development process.

Alternative development procedures may be used if they will not affect the ability of the well to provide representative samples. Wells installed with an annular seal must not be developed until 24 hours after well installation to allow annular seal materials to set or cure. ADEC recognizes that remote site work may make this impractical. Contact your ADEC project manager for site-specific approval if development is to be conducted prior to the 24-hour waiting period. Sample the monitoring well in accordance with the ADEC *Field Sampling Guidance* (ADEC August, 2017).

Well purge water can be discharged to the ground surface within 25 feet of the monitoring or recovery well casing, unless there is contamination present, or otherwise specified by the ADEC project manager. If there is evidence of contamination present, the purge water will be remediated based off of the project-specific Work Plan.

A well is considered fully developed when the following criteria are met:

- The well water is clear to the unaided eye (based on observations of water clarity through a clear glass jar); and/or
- If stability cannot be achieved, the well is considered developed when the total volume of water removed from the well equals five times the standing water volume in the well plus the volume of drilling fluid lost or potable water added (if fluids were added).

6.0 WELL DECOMMISSIONING

The purpose of decommissioning monitoring wells and temporary well points is to protect the aquifer. Monitoring wells and temporary well points should be decommissioned as soon as ADEC has determined they are no longer needed. This SOP is consistent with the decommissioning section of the *Monitoring Well Guidance* issued by the Alaska Department of Environmental Conservation (ADEC 2013). Specific monitoring well decommissioning procedures depend on project objectives and subsurface conditions, and must be discussed and presented in the project-specific Work Plan (WP). ADEC approval of the WP is required prior to decommissioning the wells.

1. Knock the bottom of the screen out with a steel drill rod/ pipe, which allows the well to be used as a tremie pipe.
2. Remove the well casing and screen until the screened interval is above the groundwater interface. This allows the material surrounding the well to collapse into the borehole. Keep a 1:1 ratio when pulling out the screen (i.e., if you have a 10' screen, pull the well out 10').
3. After the casing is withdrawn above the groundwater interface, add some bentonite chips to the well. Withdraw the casing further and continue adding bentonite chips. Continue this iterative process (pull the casing, fill the borehole, pull the casing, fill the borehole) to within 2 feet of the ground surface.
4. If the well is shallow, add water to hydrate the bentonite chips. Add additional bentonite chips as necessary to seal the well to within 2 feet of the ground surface.
5. If the well is deep, using a grout pump to place a bentonite slurry in the well. The use of the grout pump will ensure complete seal of the borehole and minimize the potential for bridging.
6. If the well is located in a confined aquifer, bentonite chips should begin to be placed within the confining stratum.
7. Fill the remaining 2 feet of the borehole with sand or gravel and restore the site as necessary.
8. Record decommissioning procedures and report to ADEC.

If the well casing and screen are unable to be removed at the time of decommissioning, and it is known that the well construction included a competent annular seal of bentonite chips surrounding the well casing, the screen should be filled with sand and the casing should be completely sealed in-place with bentonite chips up to the casing cutoff point located near the ground surface.

If the monitoring well is damaged, broken, filled or plugged with soil or other extraneous material preventing successful decommissioning efforts by the methods described previously, decommissioning can be achieved by re-drilling the monitoring well. The PVC casing and well screen may be destroyed by re-drilling the original borehole to the total depth of the well. When the auger is at the bottom of the well, bentonite chips should be added continuously as the auger is carefully removed.

7.0 REFERENCES

ADEC. 2013 (September). Monitoring Well Guidance.

ADEC. 2017 (August). Field Sampling Guidance.

ASTM. 2009 (July). *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure.* D2488. West Conshocken, Pennsylvania.

U.S. EPA .1991. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells, Office of Research and Development.

U.S. EPA, Region 4. 2008 (February). Design and Installation of Monitoring Wells, Science and Ecosystem Support Division.

ATTACHMENTS

Attachment 1 Record of Well Construction

Attachment 2 Well Development Data Sheet

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Record of Well Construction

Project		Project Number	Client	Boring No.
Address, City, State			Drilling Contractor	
Logged by	Date	Started	Drilling Method and Equipment Used	
Drill Crew		Completed		
	Groundwater Depth		Elevation	Total Depth

Depth (feet)	Diagram	Field Installation Information
1		______ Surface Monument (material ______)
2		______ Surface Seal
3		______ Bentonite Seal
4		______ Casing (material ______)
5		______ Screen (material ______)
6		______ Screen Filter (material ______)
7		______ Surface Elevation
8		______ Casing Elevation
9		______ Casing Stickup
10		______ Depth of Well
11		______ Depth of Boring
12		______ Depth to Groundwater from ______ on (date) ______
		Development Method ______
		Development Time and Purge Volume ______

Field Notes from Drilling

Date	End Time	Start Time
Note-Taker Name		Boring Number
Surface Conditions		

Well Development Data Sheet

Site Name	Event	Well ID	Project Number
Weather Conditions	**PID Readings of Total VOCs (ppm)** Ambient _______ Breathing Zone _______ In Well _______	**Date**	**Developer Initials**

Well Information

Well Material / Size (in)	Drilling Water Added (gal)	As-Built TD of Casing (ft)	Borehole Diameter(in) / Gallons per linear foot (gal/ft)
PVC / 2 SS / 2 ___/___			4.5 / 0.362 6 / 0.555 8 / 0.898 10 / 1.34 (filter pack porosity = 0.3)
Depth to Product (ft TOC)	**Depth to GW (ft TOC)**	**Initial TD of Casing (ft)**	**Product Thickness (ft) and Volume Recovered (mL)**

Borehole Vol. (BV) water table well = (TD of casing – depth to water) ∗ gal/ft; submerged well = (TD of casing – Depth Top Filter Pack *gal/ft

Min Purge Vol. = 2 * Added Water + 3 * BV Max Purge Vol. = 2 * Added Water + 10 * BV

BV = (________ ft – ________ ft) ∗ ________ gal/ft = ________ gal (* 3.785 L/gal = ________ L)

Min Purge Vol. = 2 * ________ gal + 3 * ________ gal = ________ gal (* 3.785 L/gal = ________ L)

Max Purge Vol. = 2 * ________ gal + 10 * ________ gal = ________ gal (* 3.785 L/gal = ________ L)

Well Purging Information

Start Time	Finish Time	Final TD of Casing (ft)		Equipment Used for Purging	
				sprinkler pump w/ surge block submersible pump peristaltic pump	
Color	**Odor**	**Sheen**	**Purged Dry**	**Stabilization Meters**	**Pump Intake Depth (ft btoc)**
Clear Cloudy Brown Other:	None Moderate Faint Strong	Yes No	Yes No	YSI Multi Meter Hach Turbidimeter	(during stabilization)

Purging reached: Stability Max Vol. | Purge water was: Treated Stored Other Note:

Time (HH:mm)	Volume (Gallons or Liters)		Acceptable Range to Demonstrate Stability						Water Level (feet btoc)
			± 1.0 °C	± 3%	± 10% or 0.3 mg/L (whichever is greater)	± 0.1	± 10 mV	± 10% or ±1 NTU	
	Change	Total	Temperature (°C)	Conductivity (µS/cm)	DO (mg/L)	pH (std units)	ORP (mV)	Turbidity (NTU)	

Suggested Notation

"——" = not measured "✓"= stable "+" = rising "-" = falling "*" = all parameters stable

____ Additional observations on back

Well Development Data Sheet

Site Name	Event	Well ID	Project Number
		Date	Developer Initials

Time (HH:mm)	Volume (Gallons or Liters)		Acceptable Range to Demonstrate Stability						Water Level (feet btoc)
			± 1.0 °C	± 3%	± 10% or 0.2 mg/L (whichever is greater)	± 0.2	± 10 mV	± 10% or ±1 NTU	
	Change	Total	Temperature (°C)	Conductivity (μS/cm)	DO (mg/L)	pH (std units)	ORP (mV)	Turbidity (NTU)	

STANDARD OPERATING PROCEDURE

BE-SOP-29

GeoXH GPS Location Survey

1.0 INTRODUCTION

The purpose of this Standard Operating Procedure (SOP) is to direct field personnel in the proper use of a Trimble GeoXH global positioning system (GPS) unit for the collection of location data. This SOP applies to all personnel engaged in surveying locations with a handheld Trimble GeoXH GPS. This unit is mapping-grade capable of sub-meter accuracy and should be used only when contract requirements allow for this resolution. If higher resolution/accuracy of surveyed locations is required, a survey-grade GPS should be used.

The Trimble GeoXH handheld GPS is a high precision, dual frequency, differential GPS with accuracy capabilities to the decimeter. A GeoXH 3000 and a GeoXH 6000, both running Windows Mobile with Trimble Terrasync software, may be utilized. The GeoXH 6000 has Floodlight technology, which performs better in areas with multipath errors and should be used in conditions with heavy canopy or around tall buildings.

GPS uses 24 satellites and their associated ground stations to form a world-wide radio-navigation system. The GPS receiver (the handheld GeoXH) determines the relative positions of items using the geometry of triangles (trilateration) created from the position of the receiver and the satellites it detects, and time, synchronized to universal time. A minimum of 4 satellites are needed to determine position; typically more are required for accuracy. Trimble GeoXH systems can receive up to 12 satellite positions simultaneously.

Errors can be introduced into the GPS system from a variety of sources including atmospheric conditions and physical objects causing obstructions and reflected signals. Care must be taken to ensure the best conditions for collecting location data. A tool on the Trimble GeoXH helps to plan the best time to collect locations by graphing satellite positions for the next 12 hours.

2.0 EQUIPMENT

At a minimum, the following equipment is necessary:

- Trimble GeoXH handheld unit
- External Tornado antenna and connection cable
- Range pole with level bubble and connection brackets
- Stylus
- Metal measuring tape (in feet and meters)
- Computer with internet connection and Pathfinder Office Software

Note that this SOP is intended to be used in conjunction with *Logbook Documentation and Field Notes* (BE-SOP-01).

3.0 INSTRUMENT

Prior to collecting location data, determine where the data is going to be collected, and where the nearest GPS base stations are located for differential correction of the data. The nearer the differential correction station, the greater the potential accuracy of the data. Typical base stations include continuously-operating reference stations (CORS) and UNAVCO stations. These are shown on maps at the National Geodetic Survey (NGS) website and UNAVCO website, respectively. Additional base stations are maintained by various organizations throughout Alaska such as the Department of Transportation (DOT) and universities, and can be found on those websites.

3.1 SETTING UP THE UNIT

1. Turn on the unit by pressing the green button at the bottom.
2. On the main screen, click on “GNSS Application Launcher.” This will boot the GPS program. This program can also be launched by clicking on the Start icon ( ) and selecting “Terrasync.”
3. Within the Terrasync software program, there are two stacked menus in the upper left-hand corner. They will be referred to in this SOP as the upper menu and the lower menu.
4. Click the down arrow on the upper menu and choose “Data.” This allows either creating a new file to store data (click “Create” and enter the file name and height of the antenna), or opening an existing file (click “Existing File” on the lower menu, choose the appropriate file, and click “Open”).
5. Check the number of satellites the unit is receiving signals from by clicking the down arrow in the upper menu and choosing “Status.” In the lower menu choose “Skyplot.” There should be at least 5 satellites for the unit to get lock. The satellites shown in black are the ones the unit is using to calculate position.
6. Check the settings for data collection by clicking the down arrow in the upper menu and choosing “Setup.” Click the down arrow in the lower menu and choose “Options.” These settings should typically be the following, although there may be exceptions based on site conditions. Refer to the project-specific Work Plan for details on survey setup.
   - Logging Settings:
     - Accuracy Value for Display/Logging should be Horizontal, Post-processed.
     - Post-Processing Base Distance is determined from the nearest base station
     - Use Accuracy-based Logging – Yes, and apply to all features
   - Real Time Settings:
     - Choice 1 – Integrated SBAS
     - Choice 2 – Use Uncorrected GNSS
   - GPS Settings:
     - Make sure that the GPS is connected
   - Coordinate System:
     - Use Latitude/Longitude WGS 84, Height above ellipsoid
   - Units:
     - Use US survey feet
   - External Sensors – Typically none will be used

7. Set up the range pole, brackets, and external Tornado antenna (if necessary). The internal antenna is suitable for many conditions; the Tornado antenna can improve yield under canopy and improves accuracy for post-processing. Setup the antenna (both internal and external) by clicking the down arrow in the upper menu and choosing "Setup." Click the down arrow in the lower menu and choose "Logging Settings."
    - Antenna Settings:
        - Measure Height To: Bottom of Antenna Mount for the external antenna or Bottom of Bracket for the internal.
        - Antenna Height: Use the measurement (to the thousandth of a meter) from the ground to the bottom of the antenna as show in the images below.

 

        - C Type: If using the external, choose "Tornado." If using the internal, choose "Internal."
        - Confirm: Choose how often to ask the antenna height (user preference).
8. Check the GPS status. Along the top of the screen is a notification bar.
    - A battery icon shows the remaining power left in the battery. The left half shows the charge level of the receiver battery. The right side shows the status of the computer battery. If fully green, the battery is fully charged. Yellow indicates low power and red indicates critically low.
    - A little satellite icon with a number next to it shows the number of satellites that the unit is connected to for determining position. When there are not enough satellites to calculate position, the number flashes. If the GPS is not connected, two unconnected plugs will animate.
    - When successfully locked to satellites for position, a double-headed arrow with a number above indicates the estimated accuracy. Typically, this is showing horizontal accuracy in real-time (uncorrected).
    - When collecting the location of a feature, a count appears indicating the number of seconds of occupation at that location. A bullseye with the count indicates a line or point feature rather than a point feature.

3.2 COLLECTING LOCATIONS

1. There are three types of locations, called features that can be collected with the GeoXH – points, lines, and areas.
2. To collect a point, place the GeoXH antenna on the location and ensure that it will be stationary for the entire length of the occupation (approximately 1-2 minutes).
3. Click the down arrow in the upper menu and choose "Data." Click the down arrow in the lower menu and choose "Collect."
4. Click on the type of feature to collect. This will begin collecting data to log the point. Occupy the location for at least 60 seconds. If the estimated accuracy icon indicates poor accuracy, occupy the location for longer. As the point is being collected, use the keyboard to type a name of the point. Refer to the project-specific Work Plan for naming conventions.

5. When the time has been reached to collect the point, click "Done."
6. Review collected locations by using the Map feature. Click the down arrow of the upper menu and choose "Map." This will display a map of the features that have been collected.
7. When all features have been collected, close the file by choosing "Close."

Many additional features are available with the GeoXH including offsets, background files, setting waypoints and navigating, using data dictionaries, taking photographs, and more. To use these features, refer to the GeoXH User's Manual.

3.3 DOWNLOAD DATA

Connect the GeoXH device to a computer and to download the data, follow these steps:

1. Make sure the device and the computer are switched on.
2. Make sure that the computer has the Windows Mobile Device Center (WMDC) for Windows Vista, 7 or 8, or ActiveSync for Windows XP or 2000 to be able to recognize the device when it is connected.
3. Connect the USB data cable to the device port and to the USB computer port.
4. WMDC or ActiveSync should automatically recognize the device and start a manager dialog box.
5. To transfer files manually, click on "File Management" and copy and paste files from the device to the computer. If the computer has Trimble Pathfinder Office software installed, click on the Data Transfer utility to download the location data via the software.
6. Save the files in the project folder and ensure that the Project Manager and GIS Manager know where the files are located.

3.4 POST FIELD

Once all data is downloaded to a computer, the data should be differentially corrected for maximum accuracy. Use Trimble Pathfinder Office software to differentially correct data automatically. Typically for projects in Alaska we are unable to differentially correct data real time in the field due to limited connectivity and this must be done after data collection. Base files are typically available 24 hours after the data is collected.

3.5 TROUBLESHOOTING AND MAINTENANCE

Additional details on the GeoXH device can be find in the User's Manual, which is kept in the hard case with the GPS unit at all times. The following table shows some typical problems that occur with the GeoXH.

TABLE 1: GEOXH TROUBLESHOOTING

Problem	Possible Cause	Possible Solution
The handheld will not turn on.	The battery is dead.	Recharge or swap the battery.
The handheld is not charging.	The internal temperature has risen above the allowed maximum for charging (104°F).	Remove the unit from any external heat sources and the unit will automatically start charging again when the internal temperature has dropped.
The backlight does not come on when you tap the screen or press a button.	The backlight is not set to turn on in the Backlight control.	Tap > Settings > System > Backlight to view the Backlight control and make sure that the brightness is not set to dark, and the turn on backlight box is checked.
The handheld is not receiving GNSS positions.	The integrated GNSS receiver is not activated.	Use the Connect or Activate GNSS/GPS command in the field software to open the GNSS COM port and activate the integrated GNSS receiver.
	Incorrect configuration of serial COM port.	When supplying GNSS data to an external device using the COM1 USB to serial converter cable, set the baud rate to the high-speed TSIP setting: 38400, 8, 1, Odd.
	The GNSS COM port is already in use. Only one application at a time can have the port open.	Do the following • Exit the software that is using the GNSS COM port and then retry in your application. • Check that a GNSS application is not running in the background. Tap / Task Manager and then select and close (click End Task) any GNSS applications you are not using. • Make sure that connections are not left in use by the GNSS Connector software; close the application when you are not using the connections.
	The GNSS field software is using the wrong GNSS COM port.	Connect to COM2 if the GNSS field software uses NMEA messages, or COM3 for TSIP messages. For information on which protocol to use, check the documentation for the application.
	Not enough satellites are visible.	Move to a location where the receiver has a clear view of the sky and ensure the antenna is not obstructed. Alternatively, adjust the GNSS settings to increase productivity.
	The DOP (Dilution of Precision) value for the current position is above the maximum DOP setting.	Wait until the DOP value falls below the maximum DOP specified. Alternatively, adjust the GNSS settings to increase productivity.
	Wait for real-time is selected in the GNSS field software and the integrated receiver is waiting to receive real-time corrections.	If you are collecting data for post processing, clear the wait for real-time selection.
	External antenna connected but not receiving data.	The handheld can take up to two seconds to detect that an external antenna has been connected or disconnected.

4.0 REFERENCES

Trimble 2012 (May). GeoExplorer® 3000 Series User Guide, Version 1.00, Revision B.

Trimble 2011 (February). GeoExplorer® 6000 Series User Guide, Version 1.00, Revision A.

STANDARD OPERATING PROCEDURE

BE-SOP-51

Material Handling/Manual Lifting

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes the guidelines that should be used when material handling/manual lifting at and around a job site.

2.0 GENERAL POLICY

Back injuries are one of the most common and most preventable injuries on the job site. After determining the object is within lifting capabilities, warm up by stretching before doing any lifting or strenuous work. Use proper lifting procedures - bend at the knees rather than the waist, and use your leg muscles, not your back. Keep a wide base of support by standing with legs hip distance apart, and never twist while lifting. Take proper breaks during repetitive tasks, and get help when moving heavy or awkward objects. Use lifting devices when possible. If necessary, have a competent worker or supervisor demonstrate the proper method of bending and lifting.

Identifying when materials require lifting equipment, such as slings and chokers, is key. Conduct an evaluation of the proper equipment to use to assist in lifting if manual lifting techniques are not safe.

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STANDARD OPERATING PROCEDURE

BE-SOP-52

Driver Safety Program

1.0 INTRODUCTION

This standard operating procedure (SOP) is for all individuals who will operate motorized vehicles.

2.0 DRIVER SAFETY AND POLICIES

Statistics show that many accidents involve those in company vehicles. The purpose of this SOP is to avoid injuries, possible loss of life, and costs related to accidents involving company vehicles.

2.1 COMPANY AUTO USAGE POLICIES

- Company vehicles are for company business only, and are to be driven by active employees only (unless permission is given by a supervisor) who are appropriately licensed, certified, and/or trained for the vehicle in which they are operating.
- Vehicles are to be maintained in good operating condition. Drivers will conduct a complete safety walk-around prior to entering the vehicle and inspect the vehicle on a daily basis prior to use.
- Occupants will wear seatbelts when vehicles are in motion.
- Vehicles may not be operated while using cell phones. This includes sending or receiving calls, texting, emailing or any other application on the phone (this includes personal vehicles on company business).
- Vehicles are strictly prohibited from use while under the influence of alcohol.
- Vehicles may not be operated while eating or drinking, reading, or using other devices that distract from driving.
- Vehicles must be driven within the laws and regulations for operating motorized vehicles (i.e. valid license, posted speed limits, etc.) and within the manufacturer's operating guidelines.
- Vehicles may not be used to transport alcohol.
- Vehicles must be clean of all garbage, paper, boxes, etc. when no longer in use.
- Smoking is prohibited in company vehicles.
- Vehicle loads must be secured and within the manufacturer's specs and the legal size/weight limits.
- If involved in an accident while on company business, it must be reported to the Safety Officer as soon as possible. All required forms must be completed in a timely manner.

2.2 NEAR MISS POLICY

Near misses should be reported to one's immediate supervisor and forwarded to the Safety Officer. An investigation will be conducted as soon as possible.

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STANDARD OPERATING PROCEDURE

BE-SOP-59

Site Traffic

1.0 INTRODUCTION

This standard operating procedure (SOP) is for all individuals working in and around roadways while conducting job related activities that may need to set up work zones as protection from vehicular traffic. It is also for response and recovery workers operating or working near heavy equipment who will need to establish and follow traffic safety procedures to avoid injury and equipment damage.

While OSHA requires that operators be familiar with the pieces of machinery they operate, there is also a need to implement controls to ensure these activities are performed safely. Controls are needed where multiple pieces of heavy equipment, vehicles, and response and recovery workers are in close proximity.

2.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

The following PPE is recommended for all operations:

- Hard hat
- Eye protection with side shields
- Gloves appropriate for job hazards expected (e.g., heavy-duty leather work gloves for handling debris with sharp edges and/or chemical protective gloves appropriate for potential chemical contact)
- ANSI-approved protective footwear
- High visibility safety vest

Additional PPE may be warranted depending on site conditions. This evaluation is to be made prior to commencing work activities.

3.0 PROTECTING WORKERS FROM VEHICULAR TRAFFIC

When working around traffic, the following should be used to warn oncoming traffic that there are people working in the area:

- Flaggers;
- Traffic cones;
- Flood Lights;
- “Reduce Speed” signs and/or message boards to warn approaching vehicles of the work area.

Ensure that the work zone is well lit, but control glare to avoid temporarily blinding passing motorists.

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STANDARD OPERATING PROCEDURE

BE-SOP-64

Working with Hand Tools

1.0 INTRODUCTION

This standard operating procedure (SOP) describes safe working practices that should be followed by all individuals working with hand tools.

2.0 GUIDELINES

Hand tools must be kept in proper working order. All tools must be inspected before each use and all employees must be trained to use tools with proper safety.

3.0 TOOL USE

Hand tools will be kept in good condition (undamaged handles and proper working edges) that are not cracked or mushroomed with the potential to chip or create flying objects.

When using hand tools, the tools will:

- Be used within their designated capacity
- Not be carried or left in a position that could cause injury to employees
- Be put in storage when work is finished
- Disconnected from power sources and the pressure in lines released prior to any repair work

4.0 PERSONAL PROTECTIVE EQUIPMENT

It is critical to use proper personal protective equipment (PPE) when using hand tools. When using hand tools, proper PPE will be implemented:

- Glove selection based on hand tool: leather work gloves versus cut resistant
- Safety glasses with side shields

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STANDARD OPERATING PROCEDURE

BE-SOP-66

Breathing Zone Air Monitoring

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes the guidelines for protection against occupational exposure where potential hazards exist for dust, fumes, mist, radionuclides, toxic gas, vapors, or oxygen deficiency. A Respiratory Protection Program will be implemented in accordance with Occupational Safety and Health Administration (OSHA) Standard 29 CFR 1910.134 and USACE's Safety and Health Requirements Manual (USACE 2014).

Breathing zone screening measurements will be periodically collected during activities which warrant air monitoring with a photoionization detector (PID) or colorimetric gas detector tubes to verify that workers are not exposed to contaminants above the levels specified in the project-specific Work Plan. Although not anticipated, if the levels exceed established thresholds, work at the location will be stopped and the respiratory protection program will be updated as necessary.

Downwind locations may also be monitored, as described in the Work Plan.

2.0 MATERIALS AND EQUIPMENT

Air Monitoring Equipment includes but is not limited to:

- PID equipped with a 9.8-, 10.6-, or 11.7-electron volt lamp
- Colorimetric gas detector tubes
- Personal Protective Equipment (PPE)

3.0 PROCEDURE

Under supervision of the site safety and health officer (SSHO), air monitoring will be conducted where contaminant-bearing vapors or dust, lead dust, POLs, or other air-borne contaminants of concern may be present. The project-specific Work Plan will provide air monitoring requirements and action levels for the sites. The type and extent of monitoring will depend upon site-specific conditions and the contaminants encountered at the sites. If a change in conditions is observed at either site, additional air monitoring may be required.

3.1 AIR MONITORING WITH A PID

PIDs should be calibrated daily and tested regularly, as described in the *Field Screening with a PID SOP* (BE-SOP-15).

Prior to PID use, background levels must be established by monitoring outside the exclusion zone or controlled area and upwind of the site.

Once background levels are established, begin taking readings. The PID reads in units of parts per million (ppm), and the readings should be sustained for at least one minute to determine exposure. Record readings on a regular basis. If readings exceed thresholds established in the Work Plan, work will be stopped and the SSHO or superintendent will be notified to determine the appropriate course of action.

3.1.1 Benzene

The PID method is not sensitive enough to detect harmful levels of benzene. If the PID detects organic vapors (readings greater than 1 ppm above background) in the breathing zone at a site where benzene is a known contaminant of concern, the breathing zone shall be tested with a direct reading instrument for benzene. If benzene is detected, personnel will wear passive dosimeters and will modify procedures in accordance with the project-specific Work Plan. The AHAs will also address the required PPE for potential exposure for specific activities. Conditions that exceed project action levels will require an upgrade of PPE until monitoring demonstrates otherwise. The SSHO, with the assistance of trained field personnel, will identify these conditions.

3.2 AIR MONITORING WITH COLORIMETERIC GAS DETECITON TUBES

Instructions for using colorimetric gas detection tubes vary by manufacturer. Always review and follow the manufacturer directions, which are usually printed on the box.

Instructions usually include the following:

- Break both sides of the tube being careful not to puncture or cut skin
- Place the tube in the appropriate pump in the correct orientation. Only use pumps that are in good condition and regularly maintained.
- Draw a fixed volume of gas into the tube. Follow directions to ensure the appropriate volume is being drawn into the tube.
- Wait the appropriate amount of time and then immediately measure the color change. Colors may fade with time.
- Make any humidly or temperature corrections if necessary.
- Record results.

If readings exceed thresholds established in the Site-Specific Health and Safety Plan work will be stopped and the SSHO or superintendent will be notified to determine the appropriate course of action.

4.0 REFERENCES

U.S. Army Corps of Engineers (USACE). 2014 (November). Safety and Health Requirements Manual. EM385-1-1.