2021 Groundwater Monitoring Program Work Plan

Kenai Peninsula Sites

Alaska

Beaver Creek Unit, Cannery Loop Unit, and Kenai Gas Field Contaminated Sites

Kenai, Alaska

Prepared For:

Hilcorp Alaska, LLC

Hilcorp Alaska, LLC
3800 Centerpoint Drive, Suite 1400
Anchorage, Alaska 99503

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Prepared By:

Brice ANC 8(a) ENGINEERING

Brice Engineering, LLC
3700 Centerpoint Drive, Suite 8223
Anchorage, Alaska 99503
907.275.2899 PH
www.BriceEng.com

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ACRONYMS AND ABBREVIATIONS

~	approximately
°	degrees
°C	degree(s) Celsius
‘	feet
“	inches
>	greater than
<	less than
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	Beaver Creek Unit Pad 4
BESC	Brice Environmental Services Corporation
bgs	below ground surface
BLM	Bureau of Land Management
Brice	Brice Engineering, LLC
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
GRO	gasoline-range organics
HC	hydrocarbon
HCl	hydrochloric acid
Hilcorp	Hilcorp Alaska, LLC
HVE	high vacuum extraction
ID	identification number
KGF	Kenai Gas Field
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)
Oasis	Oasis Environmental Inc.

ACRONYMS AND ABBREVIATIONS (continued)

PAH	polycyclic aromatic hydrocarbon(s)
PID	photoionization detector
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 Engineering, LLC (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 (BCU4), 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 BCU4 North and 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 2021 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 BCU, CLU, 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
Jacob Nordwall	Hilcorp	BCU, CLU & KGF Health and Safety	907.777.8418 (O) 907.748.0753 (C)	jacob.nordwall@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 / Mike Morgan	Hilcorp	BCU Lead Operator	907.283.1316 907.283.1317	mchivers@hilcorp.com mmorgan@hilcorp.com
Kraig McGhie / Andy Graves	Hilcorp	CLU & KGF Lead Operators	907.283.1345 907.283.1305	kmcghie@hilcorp.com agraves@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
Zachary Rasmussen	Brice	Environmental Scientist	907.275.2896 (O) 907.350.6483 (C)	zrasmussen@briceenvironmental.com
Jacob Bougere	Brice	Environmental Engineer	907.277.1277 (O) 907.230.6983 (C)	jbougere@briceeng.com
Victoria Pennick	Brice	Chemist	907.205.9892 (C)	vpennick@briceenvironmental.com
Peter Campbell	ADEC	BCU, CLU, & KGF Regulatory Specialist	907.262.3412	peter.campbell@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 2021 groundwater sampling effort.

Table 1-2: Site Summary

Site Name	Wells	ADEC File Number	ADEC Hazard ID Number	2021 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	4	16	2	0	1	0
CLU3	14	2320.38.012	2063	7	14	0	0	2	2
KGF Pad 14-6	27	2320.38.029	2434	13	27	3	8	0	0
KGF Pad 34-31	16	2320.38.031	3331	10	16	0	0	0	0
KGF Pad 41-7	15	2320.38.032	3191	14	15	0	7	3	5
KGF Pad 41-18	14	2320.38.033	3189	9	14	0	5	3	3

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

Table 1-2: Site Summary (continued)

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 2020). 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 2018b). In 2017, petroleum-related volatile organic compounds (VOCs) (including BTEX) and PAH were added to the analytical suite per ADEC request and based on 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 ADEC Table C groundwater 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 Environmental Services Corporation [BESC] 2019a). Per ADEC conditional acceptance of 2017 Groundwater Monitoring Reports, full-list petroleum-related VOCs and PAH were reincorporated into the 2019 Work Plans for all sites to verify any added analytical data from the first sampling event. The programmatic sampling suite will be evaluated at each biennial event to remove VOC and polycyclic aromatic hydrocarbon (PAH) analytes from the sampling suite where observed well concentrations are either non-detect or less than 20% of ADEC cleanup levels in two consecutive sampling events. Current ADEC Table C 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

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

Analyte	ADEC Cleanup Level[1] [µg/L]
Fluorene	290
Indeno[1,2,3-cd]pyrene	0.19
Naphthalene	1.7
Phenanthrene	170
Pyrene	120
Other	
Ethylene glycol[4]	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 2020).
2 Not included in TAqH calculation.
3 Surface water quality criteria from 18 AAC 70.020 (ADEC 2018b).
4 Not analyzed during 2021 event.

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
Final Work Plan	06/09/2019
Fieldwork	06/30/2019 to 07/23/2021
Reporting	08/12/2021 to 11/18/2021

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 complete Hilcorp's online Wildlife Interaction and Avoidance Training. Also, personnel will use 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 top of casing (btoc), 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 SOP BE-SOP-21 *Groundwater and LNAPL Measurements* (Appendix B).

Gauge data from all viable wells will be represented in the groundwater contour modeling and groundwater flow direction interpretations. For wells containing LNAPL, groundwater elevation will be estimated by applying a conversion factor (based on an assumed density) to the measured groundwater and LNAPL elevations.

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% 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. Wells exhibiting biological infiltration will be redeveloped prior to sampling.

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 (mL) per minute (mL/min) (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 groundwater 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 light non-aqueous phase liquid (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 2018b).

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. 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., 0721 indicates July 2021

For example, a sample collected in July 2021 from well AP-4 at the BCU Pad 4 North site would be labeled "BCP4N-AP4-0721." 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-0721."

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 (HC 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 (HC 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	US Ecology	Transfer to Hilcorp for offsite disposal through US Ecology.
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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4.0 SITE-SPECIFIC INFORMATION – BEAVER CREEK UNIT PAD 4

The BCU project area includes two sites, BCU4 North and BCU4 South, which are a part of the North Kenai assets (Figure 2).

BCU Pad 4 was constructed by Marathon Oil Company (Marathon) in 1966 to facilitate natural gas and crude oil production in the area. A production well with two reserve pits was drilled in 1972 and produced crude oil. Drilling muds were buried in the western reserve pit. Additional infrastructure, ranging from production facilities to offices, was constructed on the pad. In 2000, ADEC granted closure of the western reserve pit (SLR International Corporation [SLR] 2014f). Environmental investigations and monitoring activities have been conducted at BCU4 South (Figure 2) since 1990 and at BCU4 North since 2016.

The following subsections include information about site geology and hydrogeology as well as site-specific details about previous investigations and groundwater monitoring, well maintenance summary, and planned 2021 groundwater monitoring activities at BCU4 North and BCU4 South. Figures in Appendix A present the sites and well locations.

4.1 BCU4 Geology and Hydrogeology

BCU4 is located on glaciolacustrine deposits from the Holocene and Upper Pleistocene. Complex stratigraphy underlies BCU4, with relatively thick silt aquitards above thinly bedded water-bearing sand intervals. Clayey silt and clayey sand intervals occur at approximately 20 feet below ground surface (bgs) and deeper (SLR 2014f).

Historical groundwater elevations at BCU4 (measured between 2010 and 2016) range from 122 to 141 feet (relative to the North American Vertical Datum of 1988 [NAVD88]). At BCU4 South, where there is a much longer record of groundwater elevation measurements, groundwater flow direction has historically been interpreted as west to east with mounding in the vicinity of monitoring well AP-10 (which was replaced with well AP-10R in 2016) during summer/fall sampling events. At the southwest extent of BCU4 South, groundwater flow direction has been interpreted to be toward the northeast (SLR 2014f).

In 2017, groundwater elevation at BCU4 ranged between 126 and 138 feet (NAVD88) and groundwater flow direction of BCU4 in 2017 (west-southwest) was consistent with historical observations of west-southwest with mounding in the vicinity of the Generator Building and across the road to the east (BESC 2018b).

In 2018, groundwater elevation at BCU4 North ranged between 130 and 135 feet (NAVD88) and groundwater flow direction of BCU4 North in 2018 (southwest) was also consistent with these observations (BESC 2019d). At the southwestern corner of the BCU4 South area, groundwater elevations indicated that the flow direction may be reversed, flowing to the northeast (BESC 2018b). This interpretation is consistent with historically determined groundwater flow directions for BCU4 South (SLR 2014f). The additional groundwater elevation data collected from the BCU4 North wells installed in 2016 (AP-35, AP-36, AP-38, and AP-39) added a significant component of southwest groundwater flow to the interpreted hydrologic conditions (BESC 2017).

In 2019, groundwater elevations ranged between 130 and 137 feet at BCU4, which is consistent with historical observations. Direction of groundwater flow was inferred to be to the south and to the south-southwest across BCU4 North and to the west across most of BCU4 South during July 2019. Mounding in the vicinity of the Generator Building and across the road to the east was not observed in 2019. At the southwestern corner of the BCU4 South area, groundwater elevations indicated that the flow direction may be reversed, flowing to the southeast (BESC 2019c). These interpretations slightly deviated from 2017 and 2018 observations (BESC 2019d, 2018b) and are largely inconsistent with historical observations, which infer groundwater flow generally to the east across BCU4 North and generally to the northeast across BCU4 South (BESC 2018b, 2016f; SLR 2014f).

4.2 BCU4 North

BCU4 North is located approximately 50 air miles southwest of Anchorage, Alaska, and approximately 12 miles northeast of Kenai, Alaska (Figure 1). It is located in the Oil Truck and Loading Facility area, northeast of BCU4 South, at latitude 60°39’31.8”N, longitude 151°2’14.21”W, on land leased from U.S. Fish and Wildlife Service within the Kenai National Wildlife Refuge (Figure 2). Hilcorp took over the lease and operations of the facility from Marathon in 2013.

4.2.1 BCU4 North Previous Investigation and Monitoring Activities

At approximately 0400 on 21 July 2016, crews operating at the BCU4 facility identified a crude oil leak coming from the ground near the oil loading dock and began removing impacted material. Approximately 60 cubic yards (cy) of material was removed during this initial response, exposing four oil lines oriented north/south and three additional lines running in the transverse direction. Subsequent investigation identified a leak in one of the four oil lines. The leak was repaired, and integrity testing was performed on the oil lines, all of which passed successfully.

Follow-on remedial activities conducted in 2016 included decommissioning and removal of oil lines, removal and disposal of an additional approximately 650 cy of impacted material, installation of four additional wells around the area of release, and soil and groundwater sampling and analysis. Excavation confirmation soil samples were analyzed for GRO, DRO, RRO, and BTEX; two samples with the highest photoionization detector (PID) screening results were also analyzed for PAH. Excavation confirmation soil sample results indicated that contaminants (including GRO, DRO, RRO, BTEX, and several PAH) remained in the excavation floor and east and west sidewalls at concentrations exceeding ADEC Method Two cleanup levels in effect at that time. Additional material could not be removed due to site constraints; therefore, the excavation was lined with indicator fabric and backfilled with clean material. Analytical results for groundwater samples collected from the surrounding wells indicated that concentrations of GRO, DRO, RRO, and BTEX were either non-detect or were below ADEC Table C groundwater cleanup levels. The 2016 report recommended that the wells surrounding the area of release be incorporated into the monitoring program to assess for potential migration of contaminants (BESC 2017).

In 2017, monitoring wells AP-4, AP-35, AP-36, and AP-38 were sampled for GRO, DRO, RRO, petroleum-related VOCs (including BTEX), and PAH. Monitoring well AP-39 was purged dry and had insufficient recharge for sampling. All results for sampled wells were either non-detect or were detected at concentrations below ADEC Table C groundwater cleanup levels, consistent with 2016 monitoring results (BESC 2018b).

In 2018, ADEC requested annual sampling of GRO, DRO, RRO, petroleum-related VOCs (including BTEX), and PAH until 2022 for monitoring wells AP-4, AP-35, AP-36, AP-38, and AP-39. The analyte list was based on soil exceedances identified from the 2016 contaminated soil excavation (ADEC 2018a). After completing 5 years of annual monitoring, the need for continued monitoring will be evaluated based on analytical results. Monitoring wells AP-4, AP-35, AP-36, and AP-38 were sampled for GRO, DRO, RRO, petroleum-related VOCs (including BTEX), and PAH. AP-39 was purged dry during redevelopment activities and did not recover enough volume after 24 hours to be sampled. All results for sampled wells were either non-detect or were detected at concentrations below ADEC Table C groundwater cleanup levels, which is consistent with historical results (BESC 2019d).

In 2019, monitoring wells AP-4, AP-35, AP-36, AP-38, and AP-39 were sampled for GRO, DRO, RRO, petroleum-related VOCs (including BTEX), and PAH. Analytical results from monitoring well AP-39 indicated that DRO, benzene, ethylbenzene, and total xylenes were detected at concentrations above the ADEC Table C groundwater cleanup levels. It is important to note that 2019 was the first year AP-39 was sampled without being purged dry. All other results were either non-detect or were detected at concentrations below ADEC Table C groundwater cleanup levels. Monitoring well AP-39 was sampled using a peristaltic pump because it had previously purged dry in 2017 due to slow recharge with little volume; however, water column length in AP-39 was observed to be sufficient for future bladder pump use. During monitoring well inspection and maintenance activities, wells were observed to be in generally good condition and require little maintenance (BESC 2019c).

Monitoring wells were not sampled in 2020 due to the COVID-19 epidemic.

4.2.2 BCU4 North 2021 Monitoring Well Inspection and Maintenance

All BCU4 North 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 4-1 includes a well maintenance summary for BCU4 North.

Table 4-1: BCU4 North Well Maintenance Summary

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
AP-4	Good				26.58	2”	
AP-35	Good				16.32	2”	Flush mount.
AP-36	Good				17.58	2”	
AP-38	Good				14.25	2”	
AP-39	Good				17.09	2”	Sampled in 2019 despite continuous drawdown. Purged dry and not sampled in 2017.

Notes:
For definitions, see the Acronyms and Abbreviations section.
1 All wells Schedule 40 PVC unless otherwise indicated.

4.2.3 BCU4 North 2021 Groundwater Monitoring Activities

BCU4 North groundwater sampling is conducted annually to determine if contaminants are migrating through the soils to the groundwater. All viable wells are gauged during each sampling event. The planned field activities for the 2021 groundwater monitoring at BCU4 North are summarized below:

- The vegetation at and surrounding BCU4 North will be visually assessed for potential offsite migration of contaminants. The visual assessment will focus on signs of stressed vegetation and/or impacts to wetlands and surface water.
- Gauge groundwater levels in all monitoring wells within a 2-hour period in order to determine groundwater elevation and flow direction.
- AP-4, AP-35, AP-36, AP-38, and AP-39: Sample for GRO, DRO, RRO, BTEX, 1,2,4-trimethylbenzene, and naphthalene.

- Resurvey all BCU4 North wells during decommission/installation activities completed under a separate work plan to determine top of casing elevations.

Table 4-2 identifies the BCU4 North wells and sample analyses. Monitoring well locations are presented on Figure 5.

Table 4-2: BCU4 North Summary of Monitoring Wells and 2021 Analyses

Well ID	Gauge	ANALYSES / METHOD				
		AK101	AK102	AK103	SW8260C	SW8270D SIM
		GRO	DRO	RRO	VOCs[1]	PAH[2]
AP-4	X	X	X	X	X	X
AP-35	X	X	X	X	X	X
AP-36	X	X	X	X	X	X
AP-38	X	X	X	X	X	X
AP-39	X	X	X	X	X	X

Notes:
For definitions, see the Acronyms and Abbreviations section.
[1] Petroleum-related VOC analytes reduced in 2019 to include only BTEX and 1,2,4-trimethylbenzene.
[2] PAH analytes reduced in 2019 to include only naphthalene.

4.3 BCU4 South

BCU4 South is located approximately 50 air miles southwest of Anchorage, Alaska, and approximately 12 miles northeast of Kenai, Alaska, as shown on Figure 1. BCU4 South is located adjacent to and southwest of BCU4 North (Figure 2). BCU4 South was constructed by Marathon in 1966 to facilitate natural gas and crude oil production in the area. A production well with two reserve pits was drilled in 1972 and produced crude oil. Drilling muds were buried in the Western Reserve pit. Additional infrastructure, ranging from production facilities to offices, was constructed on the pad. In 2000, ADEC granted closure of the Western Reserve pit (SLR 2014f). Environmental investigations and monitoring activities have been conducted at BCU4 South since 1990. Hilcorp took over the lease and operations of the facility from Marathon in 2013.

4.3.1 BCU4 South Previous Investigations and Monitoring Activities

In 1990, a diesel spill was encountered near the Generator Building south of the Office/Shop Building. Between September 1990 and September 1991, approximately 984 cy of diesel-impacted soil was removed near the Generator Building and thermally treated. The extent of the excavation was reportedly limited by proximity to the Generator Building and the main access road. Two soil borings and groundwater monitoring wells were installed to assess contamination of soil and groundwater (SLR 2014f).

Monitoring assets were established between the 1990 initial response and 1992 investigations to determine the contaminant boundary. Routine groundwater monitoring began in 1995 for annual and biennial gauging and sampling for GRO, DRO, RRO, and BTEX. In 1998, only quarterly gauging of static water levels and LNAPL thickness were completed. Passive free-product-recovery skimmers were installed in monitoring wells AP-9 and AP-15, but AP-9 was abandoned in 1999. Monitoring well AP-29 was installed in 2000 near the original AP-9 location, drilled at an angle of approximately 28° from vertical to reach under the Generator Building (Oasis Environmental Inc. [Oasis] 2001). Groundwater flow and contaminant concentrations indicated that two aboveground storage tanks were the likely sources of contamination. Although no longer onsite, one tank was located next to the existing Generator Building, and one tank was located near a previous generator building near AP-15 (Oasis 2008).

Additional investigations from additional potential sources (including a drum of waste sediment and water, and a septic system) were conducted between 2000 and 2008, with analytical gas chromatograms indicating a contribution to DRO concentrations by glycol compounds of an unknown source. Fecal coliform was not detected in wells AP-10 and AP-25; therefore, the possible impact from the septic system leachate was deemed inconclusive. Additional delineation of glycol impacts at this location was deemed unnecessary by ADEC due to the low concentration and intermittent nature of the exceedances. Groundwater sample results for all other parameters did not exceed associated ADEC Table C groundwater cleanup levels during the 2008 assessment (SLR 2014f).

In 2008, soil gas testing was conducted to evaluate potential biodegradation remedial activities and ongoing natural attenuation, with the conclusion that observed oxygen deficiency and carbon dioxide surplus suggested aerobic biodegradation of organic constituents, or that biodegradation could be causing anaerobic conditions. It was also concluded that the addition of oxygen to contaminated zones could stimulate natural attenuation of present contaminants. Petropore™ passive skimmers were deployed in monitoring wells AP-15 and AP-29 because of previously reported LNAPL; however, removal of these skimmers was recommended due to a reported lack of recovery (SLR 2014f).

In 2011, groundwater monitoring activities were completed between 19 October and 4 November. All DRO sample results were less than the ADEC Table C groundwater cleanup levels in the Generator Building plume area near AP-26. The two passive skimmers in wells AP-15 and AP-29 were removed, and free-product was still noted in these wells. Samples were collected from three monitoring wells in the Compressor and Manifold Building area. No impact was indicated at well AP-32 (the furthest downgradient well onsite), and DRO was detected at concentrations less than ADEC Table C groundwater cleanup levels in samples from AP-3 and AP-33 (SLR 2014f).

In 2015, groundwater monitoring results indicated that all DRO and BTEX concentrations (excluding DRO in AP-10) were non-detect or were below ADEC Table C groundwater cleanup levels. Ethylene glycol was not detected in any samples and is no longer regarded as a contaminant of concern. Measurable LNAPL was observed in AP-15 and AP-29 (0.10 and 0.14 feet thick, respectively). A total of approximately 0.5-gallons of product was removed from AP-15 and AP-29 and disposed with purge water at BCU4 South (BESC 2016f).

In 2016, well AP-10 was decommissioned and replaced with well AP-10R.

In 2017, two monitoring wells were sampled for DRO, petroleum-related VOCs (including BTEX), and PAH at BCU4 South: AP-10R (purged dry and sampled the following day) and AP-25. Concentrations of DRO, ethylbenzene, and naphthalene exceeded the ADEC Table C groundwater cleanup levels. Concentrations of 1,2,4-trimethylbenzene exceeded ADEC Table C groundwater cleanup levels at the time of the 2017 sampling event, but those same concentrations did not exceed updated ADEC Table C groundwater cleanup levels (amended through 27 October 2018). Results for all other analytes were either non-detect or were detected at concentrations less than the ADEC Table C groundwater cleanup levels. Monitoring wells AP-15 and AP-29 contained LNAPL and were not sampled. Depth to product was detected at 21.02 feet below top-of-casing at monitoring well AP-15, and depth to product was not recorded for AP-29 because product thickness was too thin to measure. Absorbent socks were placed in both wells (BESC 2018b).

In 2019, monitoring wells, AP-3, AP-4, AP-10R, AP-14, AP-25, AP-28, AP-30, AP-31, AP-33, and AP-34, were sampled for DRO, petroleum-related VOCs (including BTEX), and PAH. In addition, well AP-3 was sampled for ethylene glycol. Monitoring well AP-10R was sampled using a peristaltic pump (because it purged dry in 2017) and recharged slowly to have a water column shorter than the length of a bladder pump. Analytical results from monitoring well AP-10R exhibited concentration levels of DRO and naphthalene (1,530 µg/L and 2.6 µg/L, respectively) exceeding current ADEC Table C groundwater cleanup levels, consistent with historical results. Concentrations of 1,2,4-trimethylbenzene and ethylbenzene have historically been detected in AP-10R but were not detected in 2019. All other analytical results were either non-detect or were detected at concentrations below ADEC Table C groundwater cleanup levels. LNAPL was detected in monitoring wells AP-15 and AP-29, and these wells were not sampled. Product thickness was measured at 0.64 foot in monitoring well AP-15, and approximately 1 gallon of product was removed during product recovery efforts. Product thickness was measured at 2.43 feet in monitoring well AP-29, and approximately 2 gallons of product was removed during product recovery efforts. Absorbent socks were replaced in both wells. During monitoring well inspection and maintenance activities, wells were observed to be in generally good condition and required little maintenance (BESC 2019c).

4.3.2 BCU4 South 2021 Monitoring Well Inspections and Maintenance

All BCU4 South 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 4-3 includes a well maintenance summary for BCU4 South.

Table 4-3: BCU4 South Well Maintenance Summary

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
AP-3	Good				21.8	2”	
AP-4	Good				26.58	2”	
AP-10R	Good				17.72	2”	Flush mount. Sampled in 2019; Purged dry in 2017.
AP-14	Poor				19.48	2”	No monument. Riser broken, likely by vehicle strike. PVC cut ~0.68’ in 2019.
AP-15	Fair		X	X	18.73	2”	Replace sock if LNAPL present. No monument. Rancid, solvent odor in 2019. PID reading 145 ppm.
AP-23	Good				17.25	-	
AP-24	Good				24.7	-	
AP-25	Good				26.88	4”	Overgrown with alders, causing accessibility and locating issues in 2019.
AP-26	Good				23.68	4”	No plug.
AP-27	To be decommissioned. PVC sheared.						
AP-28	Good				23.5	2”	
AP-29	Good		X	X	21.72	2”	Replace sock if LNAPL present. Well installed on 28° angle. Lubricant/solvent odor in 2019. PID reading 212 ppm.
AP-30	Good				20.75	4”	No collar or lid.
AP-31	Good				17.62	4”	
AP-32	Good				20.03	-	

Table 4-3: BCU4 South Well Maintenance Summary (continued)

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
AP-33	Good				21.47	2"	
AP-34	Good				21.23	2"	Pressure buildup; methane odor in 2019.

Notes:
For definitions, see the Acronyms and Abbreviations section.
- Unknown or not determined
1 All wells Schedule 40 PVC unless otherwise indicated.
2 Shaded rows indicate wells to be decommissioned. Wells to be decommissioned are addressed under a separate work plan.

4.3.3 BCU4 South 2021 Groundwater Monitoring Activities

BCU4 South groundwater wells are monitored on a biennial and a 4-year schedule. All viable wells are gauged during each sampling event. The planned field activities for the 2021 groundwater monitoring at BCU4 South are summarized below:

- The vegetation at and surrounding BCU4 South will be visually assessed for potential offsite migration of contaminants. The visual assessment will focus on signs of stressed vegetation and/or impacts to wetlands and surface water.
- Gauge groundwater levels in all monitoring wells within a 2-hour period in order to determine groundwater elevation and flow direction, except for monitoring well AP-27, which is scheduled for decommissioning.
- AP-15 and AP-29: Remove LNAPL and replace absorbent socks. If LNAPL is not observed, wells will be sampled for DRO, petroleum-related VOCs (including BTEX), and PAH.
- AP-10R and AP-25: Sample for DRO, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, and naphthalene, and 1-methylnaphthalene.
- AP-3: Sample for DRO and ethylene glycol at a frequency of every 4 years. This well is scheduled to be sampled in 2023.
- AP-4, AP-14, AP-28, AP-30, AP-31, AP-33, and AP-34: Sample for DRO at a frequency of every 4 years. These wells are scheduled to be sampled in 2023.
- AP-27: Decommission (decommission activities completed under a separate work plan). This well is damaged, and similar groundwater information can be obtained from nearby well AP-28.
- Resurvey all wells at BCU4 South during decommission/installation activities completed under a separate work plan to determine top of casing elevations.

Table 4-4 identifies the BCU4 South wells and sample analyses. Monitoring well locations are presented on Figure 5.

Table 4-4: BCU4 South Summary of Monitoring Wells and 2021 Analyses

Well ID	Gauge	ANALYSES / METHOD					
		AK102	SW8260C		SW8270D SIM		SW8015C
		DRO	VOCs[1]	Select VOCs[2]	PAH[1]	Select PAH[3]	Ethylene glycol
AP-3	X						
AP-4	X						
AP-10R	X	X		X		X	
AP-14	X						
AP-15	X	X	X		X		
AP-23	X						
AP-24	X						
AP-25	X	X		X		X	
AP-26	X						
AP-28	X						
AP-29	X	X	X		X		
AP-30	X						
AP-31	X						
AP-32	X						
AP-33	X						
AP-34	X						

Notes:
For definitions, see the Acronyms and Abbreviations section.
Yellow highlight indicates that LNAPL was observed in the well in 2019. Samples will be collected if no LNAPL is observed during 2021 activities.
[1] Full list analysis. Petroleum-related VOCs include BTEX.
[2] Petroleum-related VOC analytes reduced in 2019 to include only 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, and ethylbenzene.
[3] PAH analytes reduced in 2019 to include only naphthalene and 1-methylnaphthalene.

5.0 SITE-SPECIFIC INFORMATION – CANNERY LOOP UNIT PAD 3

CLU3 is located approximately 60 air miles southwest of Anchorage, Alaska, on the Kenai Peninsula, as shown on Figure 1. CLU3 is located at 500 Childs Avenue, off the Bridge Access Road near Kenai, Alaska (Figure 3).

A borehole at CLU3 was advanced in 1981, identifying dry gas-bearing reservoir strata within three distinct lithologic units defined as the Cannery Loop Extension (Alaska Oil and Gas Conservation Commission [AOGCC] 1987). Drilling fluids and natural gas condensate (NGC) associated with reserve pits and miscellaneous spills have resulted in hydrocarbon contamination of soil and groundwater (SLR 2014e).

The following sections include site-specific information about site geology and hydrogeology, previous investigations and groundwater monitoring, well maintenance summary, and planned 2021 groundwater monitoring activities at CLU3. Figure 6 (Appendix A) presents the site location, well locations, and groundwater flow direction.

5.1 CLU3 Geology and Hydrogeology

CLU3 is located on Holocene and Upper Pleistocene glaciolacustrine deposits. The gravel pad is positioned on an organic soil horizon, up to 6 feet thick, underlain by layers of sand and silt to a depth of at least 15 feet (SLR 2014d).

Historical groundwater elevations measured between 2010 and 2015 ranged from 28 to 35 feet (NAVD88), and groundwater flow at CLU3 has historically been observed generally toward the west-southwest during summer/fall sampling events (Oasis 2012; SLR 2014e; BESC 2016c, 2018a, 2019e). In 2019, groundwater elevations ranged from 29.07 feet to 32.41 feet and were observed to be slightly lower than groundwater elevation data from 2017 (31 to 35 feet [NAVD88]), with a groundwater elevation difference ranging from 0.5 feet to 2.0 feet. Groundwater flow direction was west-southwest, consistent with historical observations (BESC 2019b).

5.2 CLU3 Previous Investigations and Monitoring Activities

A borehole at CLU3 was advanced in 1981, identifying dry gas-bearing reservoir strata within three distinct lithologic units defined as the Cannery Loop Extension (AOGCC 1987). Drilling fluids and NGC associated with reserve pits and miscellaneous spills have resulted in diesel contamination of soil and groundwater (SLR 2014e).

Groundwater monitoring at CLU3 began in 1996 for GRO, DRO, RRO, and BTEX. Quarterly groundwater monitoring began in 1998 and was reduced to semi-annual monitoring in 1999. Semi-annual groundwater monitoring was further reduced to annual monitoring in 2004 and reduced again to odd-year biennial monitoring in 2011. As GRO, RRO, and BTEX exhibited historically non-detect results or these analytes were detected at concentrations below ADEC Table C groundwater cleanup levels, the list of analytes for CLU3 wells was reduced to DRO only in 2010 (Oasis 2012, SLR 2014e). Following a groundwater monitoring program optimization evaluation conducted in 2015, monitoring wells MW-7, MW-9, MW-10, and MW-11 were removed from the sampling program to biennial gauging only; and monitoring wells MW-1, MW-4, MW-5, MW-6, and MW-12 were reduced to a 4-year sampling frequency, while the remaining five monitoring wells (MW-2, MW-3, MW-8, PZ-1, and PZ-2) were retained on the odd-year biennial sampling frequency (BESC 2015).

Between 1998 and 2011, LNAPL was detected in four wells (MW-2, MW-3, PZ-1, and PZ-2), and passive skimmers were employed in three of these wells (MW-2, MW-3, and PZ-1) at various periods between 1998 and 2011, removing a total of approximately 6.5 gallons of LNAPL during that time. The skimmers were removed in 2011 after field observations noted the absence of LNAPL in all wells (Oasis 2012).

DRO has historically been identified at concentrations exceeding the ADEC Table C groundwater cleanup level in four of the 14 monitoring wells at CLU3 (MW-2, MW-3, PZ-1, and PZ-2). A 2007-2008 evaluation of the monitored natural attenuation at CLU3 concluded that both aerobic and anaerobic degradation was active and contributing to the general decrease of DRO concentrations in CLU3 groundwater (SLR 2014e). Results for all other analytes in these wells, and all other wells at the site, were either non-detect or were detected below ADEC Table C groundwater cleanup levels (SLR 2014e; BESC 2016c, 2018a).

In 2017, monitoring wells MW-2, MW-3, MW-5, MW-6, MW-8, PZ-1, and PZ-2 were sampled for DRO, petroleum-related VOCs (including BTEX), and PAH. The 2017 groundwater monitoring results indicated exceedances of ADEC Table C groundwater cleanup levels for DRO and naphthalene in monitoring wells MW-2, MW-3, PZ-1, and PZ-2. Results for all other analytes were either non-detect or below ADEC Table C groundwater cleanup levels. Several results for PAH analytes in wells MW-2 and MW-3 were non-detect with limits of quantitation exceeding ADEC Table C groundwater cleanup levels; dilution factors required during analysis for high concentrations of DRO in the sample caused these limits to be elevated. Monitoring well MW-13 was successfully decommissioned. All monitoring wells were resurveyed in 2017. Well casing elevations across the site were approximately 5.9 feet higher than previous determinations, except for monitoring well MW-11, which had an elevation difference of approximately 7 feet, resulting in apparently higher groundwater elevations in 2017 than have historically been observed. The difference in elevation was attributable to the uncertainty in the historically employed NGVD29 vertical datum combined with the 2017 resurvey of casing elevations using the NAVD88 vertical datum. The discrepancy between MW-11 and all other wells on the site is interpreted as elevation change in the MW-11 casing due to frost-jacking or heaving (BESC 2018a).

In 2019, monitoring wells MW-1, MW-2, MW-3, MW-8, MW-12, PZ-1, and PZ-2 were sampled for DRO, petroleum-related VOCs (including BTEX), and PAH. Monitoring well MW-4 was not sampled due to the presence of a red/orange sludge infiltrating the well and monitoring well MW-2 was sampled using a peristaltic pump due to monument damage preventing bladder pump descent into the well. Concentrations of DRO in monitoring wells PZ-1 and PZ-2 (3,460 µg/L and 5,910 µg/L, respectively) exceeded the ADEC Table C groundwater cleanup level of 1,500 µg/L, which is consistent with historical observations; however, DRO concentrations in monitoring wells MW-2 and MW-3 were below the ADEC Table C groundwater cleanup level for the first time. All other analytical results were either non-detect or were detected at concentrations below ADEC Table C groundwater cleanup levels. Despite observed heaving in some wells, sludge infiltration in MW-4, and the monument damage on MW-2, all other wells were in generally good condition and required little maintenance during the monitoring well inspection and maintenance activities (BESC 2019b).

5.3 CLU3 2021 Monitoring Well Inspections and Maintenance

All CLU3 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 5-1 includes a well maintenance summary for CLU3.

Table 5-1: CLU3 Well Maintenance Summary

Well ID	2019 Observations					Well Diameter[2]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
MW-1	Good				12.14	2”	Iron staining/debris on water level meter probe in 2019.
MW-2	Fair				11.94	2”	Monument and casing bent at ground surface (angled ~10°). Well obstructed. Start of screen ~6.65’ btoc. HC odor in 2019.
MW-2R	Replacement well for MW-2 to be installed.						
MW-3	Good				12.08	2”	HC odor in 2019.
MW-4	Good				11.41	2”	Thick, dark, red/orange sediment/sludge in 2019 preventing sampling.
MW-4R	Replacement well for MW-4 to be installed.						
MW-5	Good				8.03	4”	
MW-6	Good/Fair				9.11	4”	Monument concrete heaved ~5”; no impact to well.
MW-7	Good/Fair				9.64	4”	Monument concrete heaved ~5”; no impact to well.
MW-8	Fair				12.27	4”	Missing collar, unable to lock monument.
MW-9	Good				13.01	2”	
MW-10	Good				11.71	2”	
MW-11	Heaved	X			9.65	2”	
MW-12	Good				11.14	2”	
PZ-1	Good				11.5	2”	Slight HC odor in 2019.
PZ-2	Fair				11.73	2”	Slight HC odor and sheen on purge water in 2019.

Notes:
For definitions, see the Acronyms and Abbreviations section.
[1] All wells Schedule 40 PVC unless otherwise indicated.
[2] Shaded rows indicate wells previously destroyed or decommissioned.

5.4 CLU3 2021 Groundwater Monitoring Activities

CLU3 groundwater wells are monitored on a biennial and a 4-year schedule. All viable wells are gauged during each sampling event. The planned field activities for the 2021 groundwater monitoring at CLU3 are summarized below:

- The vegetation at and surrounding CLU3 will be visually assessed for potential offsite migration of contaminants. The visual assessment will focus on signs of stressed vegetation and/or impacts to wetlands and surface water.

- Gauge groundwater levels in all monitoring wells within a 2-hour period in order to determine groundwater elevations and flow direction.
- MW-2, MW-3, MW-8, PZ-1, and PZ-2: Sample for DRO, 1,2,4-trimethylbenzene, ethylbenzene, and naphthalene.
- MW-5 and MW-6: Sample for DRO, 1,2,4-trimethylbenzene, ethylbenzene, and naphthalene at a frequency of once every 4 years. The next sampling event for MW-5 and MW-6 will be in 2021.
- MW-1, MW-4, and MW-12: Sample for DRO, 1,2,4-trimethylbenzene, ethylbenzene, and naphthalene at a frequency of once every 4 years. The next sampling event for MW-1, MW-4, and MW-12 will be in 2023.
- MW-2 and MW-4: Decommission and replace (decommission/installation activities completed under a separate work plan). Monitoring well MW-2 is damaged and obstructed. Monitoring well MW-4 produced no stable groundwater to sample due to a red/orange sludge infiltration in the well.
- Resurvey all wells at CLU3 during decommission/installation activities completed under a separate work plan to determine top of casing elevations.

Table 5-2 identifies the CLU3 wells and sample analyses. Monitoring well locations are presented on Figure 6.

Table 5-2: CLU3 Summary of Monitoring Wells and 2021 Analyses

Well ID	Gauge	ANALYSES / METHOD		
		AK102	SW8260C	SW8270D SIM
		DRO	VOCs[1]	PAH[2]
MW-1	X			
MW-2	X	X	X	X
MW-3	X	X	X	X
MW-4	X			
MW-5	X	X	X	X
MW-6	X	X	X	X
MW-7	X			
MW-8	X	X	X	X
MW-9	X			
MW-10	X			
MW-11	X			
MW-12	X			
PZ-1	X	X	X	X
PZ-2	X	X	X	X

Notes:
For definitions, see the Acronyms and Abbreviations section.
1 Petroleum-related VOC analytes reduced in 2019 to include only 1,2,4-trimethylbenzene and ethylbenzene.
2 PAH analytes reduced in 2019 to include only naphthalene.

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 2021 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).

Groundwater flow at KGF Pad 14-6 has historically been observed to vary between west-northwest and west-southwest during summer/fall sampling events and west in 2015 and 2017. Groundwater elevation can fluctuate up to 5 feet seasonally (SLR 2014a). Groundwater elevations ranged between 61.63 feet and 64.52 feet (NAVD88) in 2017 (BESC 2019e). In 2019, groundwater elevations at KGF Pad 14-6 ranged between 57.05 feet and 62.89 feet (NAVD88) and groundwater flow direction was interpreted to be toward the west-southwest, which is consistent with historical observations (BESC 2019a).

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 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. A 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. 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).

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).

Seven wells (MW-1, MW-2, MW-3, MW-13, MW-14, MW-15, and MW-21) at KGF 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 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 (BESC 2016a).

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; BESC 2016a).

In 2017, monitoring wells MW-7, MW-8, MW-9, MW-17, MW-20, MW-22, MW-24, MW-26, MW-29, and MW-36 were sampled for GRO, DRO, RRO, petroleum-related VOCs (including BTEX), and PAH. Concentrations of DRO, RRO, 1,2,4-trimethylbenzene, benzene, ethylbenzene, naphthalene, and/or 1-methylnaphthalene exceeded ADEC Table C groundwater cleanup levels in all wells. Monitoring wells MW-23, MW-33, and MW-41 were not sampled due to LNAPL detected in each well, and absorbent socks were either placed or flipped; no used socks were removed. Monitoring wells MW-3R, MW-11R, MW-16, MW-17, and MW-26 were sampled via peristaltic pump due to 1.5-inch inner casing diameters. 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 (HCl) preservative. Eight surface water samples were also 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 2018b). 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 (BESC 2019e).

In 2019, monitoring wells MW-4, MW-6, MW-7, MW-8, MW-9, MW-10R, MW-17, MW-20, MW-22, MW-24, MW-25, MW-26, MW-28, MW-29, MW-33, MW-35, MW-36, MW-37, and MW-40 were sampled for DRO, RRO, petroleum-related VOCs (including BTEX), and PAH. Wells MW-4, MW-6, MW-10R, MW-25, MW-28, MW-33, MW-35, MW-37, and MW-40 were additionally sampled for GRO. Wells MW-23 and MW-41 were not sampled due to the presence of LNAPL. Approximately 0.25 gallon of product was removed from MW-23, and 1.5 gallons removed from MW-41. Well MW-11 was not sampled due to its poor condition (bent at an approximately 45-degree angle). Wells MW-10R, MW-25, and MW-26 were sampled using a peristaltic pump because well diameters were 1.5 inches or less. Volatile samples were collected by detaching the tubing prior to the paddles and decanting from the tubing. Physical properties of the groundwater at monitoring wells MW-25 and MW-26 (thin, soapy water with low meniscus) prevented elimination of headspace in the sample glassware. Surfactants and dissolved gases can affect the interfacial tension and wettability qualities of water; the observed physical properties of groundwater in these wells may be attributable to volatilization of contaminants around these wells or if surfactants were used in the HVE system during its operation. Samples were recollected from MW-8 and MW-22 due to broken glassware upon arrival at the laboratory preventing analysis. Concentrations of DRO, RRO, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, naphthalene, total xylenes, 1-methylnaphthalene, and/or 2-methylnaphthalene exceeded ADEC Table C groundwater cleanup levels in wells MW-7, MW-8, MW-9, MW-17, MW-20, MW-22, MW-24, MW-25, MW-26, MW-29, MW-33, and MW-36. Results for all other analytes were either non-detect or were detected at concentrations below ADEC Table C groundwater cleanup levels. Contaminant concentrations were observed to be generally consistent with historical observations, showing a continuing decrease in analyte concentrations. Eight surface water samples were scheduled for collection in 2019; however, a lack of surface water available at KGF Pad 14-6 prevented sample collection. During monitoring well inspections and maintenance, several wells were observed to be in poor condition: well MW-11 was bent at a 45-degree angle, heaving was observed at wells MW-17, MW-28, and MW-31, and well MW-8 appeared to be in good condition when inspected and sampled in June and July; however, when resampled in September, the well contained an obstruction and high turbidity was observed, possibly indicating a sheared well screen or riser. All other wells were in generally good condition and required little maintenance (BESC 2019a).

In 2020, monitoring wells MW-11, MW-12, and MW-30 were decommissioned during the winter. These particular wells, with the exception of MW-30, were inaccessible during the summer months due to their location in the wetland; thus, were only able to be decommissioned during winter months. Well MW-30 was decommissioned because it was removed from the sampling program and was buried under 8-inches of gravel.

6.1.3 KGF Pad 14-6 2021 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	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	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				8.05	4”	
MW-5	Fair	X			7.61	2”	Monument slanted; no lock.

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

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
MW-6	Good				7.45	2”	
MW-7	Good				7.16	2”	Slight HC odor in 2019. Data loggers (Solinst Levelogger and Barologger) in well.
MW-8	Good				6.09	2”	Obstruction ~9-10’ btoc (identified during resample in 2019).
MW-9	Good				6.39	2”	
MW-10R	Good				5.7	1”	Needs 1.5” plug.
MW-11	Decommissioned in 2020.						
MW-12	Decommissioned in 2020.						
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	Fair	X			8.59	4”	Heaved. Broken lid. Slight HC odor in 2019. PVC cut ~0.64”.
MW-18	HVE (4” well diameter)						
MW-20	Good				8.42	4”	Moderate HC odor in 2019.
MW-21	HVE (4” well diameter)						
MW-22	Good				8.39	4”	No cap.
MW-23	Good		X	X	8.45	4”	Replace sock if LNAPL present. Strong HC odor in 2019. Well PID reading 45 ppm. Dedicated bailer in well.
MW-24	Good	X			8.57	4”	Well cap pushed against lid; loose cap.
MW-25	Good				5.59	1”	Metal casing. No lock or plug.
MW-26	Good				6.95	1”	Metal casing.
MW-27	Good				8.09	4”	No cap.
MW-28	Good	X			7.56	4”	Slightly heaved.
MW-29	Good				6.52	4”	
MW-30	Decommissioned in 2020.						
MW-31	Good	X			7.45	4”	No lid. Slightly heaved. Very slight HC odor in 2019. Very difficult to remove cap because PVC jammed into cover.
MW-33	Good		X	X	5.27	4”	Replace sock if LNAPL present. Removed <0.1 gallon LNAPL in 2019; sufficient to sample. Barologger in

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

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
							well. Strong HC odor. Well PID reading 13.2 ppm; ambient PID reading 0.6 ppm. Dedicated bailer in well.
MW-34	Good				3.49	4”	No plug.
MW-35	Good				6.77	4”	
MW-36	Good				6.59	4”	No monument. Slight to moderate HC odor in 2019.
MW-37	Good				6.36	4”	No monument.
MW-38	Good				5.44	2”	
MW-39	Good				5.79	4”	
MW-40	Good				5.7	2”	
MW-41	Good		X	X	8.29	1”	Replace sock if LNAPL present. Basket in well. Strong, light HC odor. Well PID reading 102 ppm; ambient PID reading 0.5 ppm. Dedicated bailer.

Notes:
For definitions, see the Acronyms and Abbreviations section.
- Unknown or not determined
1 All wells Schedule 40 PVC unless otherwise indicated.
2 Shaded rows indicate wells decommissioned or inaccessible due to incorporation into HVE system.

6.1.4 KGF Pad 14-6 2021 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 2021 groundwater monitoring at KGF Pad 14-6 are summarized below:

- The vegetation at and surrounding KGF Pad 14-6 will be visually assessed for potential offsite migration of contaminants. The visual assessment will focus on signs of stressed vegetation and/or impacts to wetlands and surface water.
- Gauge groundwater levels in all monitoring wells within a 2-hour period to determine groundwater elevations and flow direction.
- 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-23, MW-33, and MW-41: Remove LNAPL and install or replace 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 absorbent socks or sampling equipment.

- 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, 1,3,5-trimethylbenzene, benzene, ethylbenzene, naphthalene, xylenes, 1-methylnaphthalene, and 2-methylnaphthalene.
- MW-4, MW-6, MW-10R, 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 2023.
- Resurvey all KGF Pad 14-6 wells during decommission/installation activities completed under a separate work plan to determine top of casing elevations.

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 2021 Analyses

Well ID	Gauge	ANALYSES / METHOD						
		AK101	AK102	AK103	SW8260C		SW8270D SIM	
		GRO	DRO	RRO	VOCs[1]	Select VOCs[2]	PAH[1]	Select PAH[4]
MW-4	X							
MW-5	X							
MW-6	X							
MW-7	X		X	X		X		X
MW-8	X		X	X		X		X
MW-9	X		X	X		X		X
MW-10R	X							
MW-17	X		X	X		X		X
MW-20	X		X	X		X		X
MW-22	X		X	X		X		X
MW-23	X	X	X	X	X		X	
MW-24	X		X	X		X		X
MW-25	X							
MW-26	X		X	X		X		X
MW-27	X							
MW-28	X							
MW-29	X		X	X		X		X
MW-31	X							
MW-33	X	X	X	X	X		X	
MW-34	X							
MW-35	X							
MW-36	X		X	X		X		X
MW-37	X							
MW-38	X							
MW-39	X							
MW-40	X							

Table 6 2: KGF Pad 14-6 Summary of Monitoring Wells and 2021 Analyses (continued)

Well ID	Gauge	ANALYSES / METHOD						
		AK101	AK102	AK103	SW8260C		SW8270D SIM	
		GRO	DRO	RRO	VOCs[1]	Select VOCs[2]	PAH[1]	Select PAH[4]
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 2019. Samples will be collected if no LNAPL is observed during 2021 activities.
- Not applicable
[1] Full list analysis. Petroleum-related VOCs include BTEX.
[2] Petroleum-related VOC analytes reduced in 2019 to include only 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, and xylenes.
[3] PAH analytes reduced in 2019 to include only naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene.

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).

Groundwater flow at KGF Pad 34-31 has historically been observed to flow to the west-northwest during summer/fall sampling events (SLR 2014b). In 2017, groundwater elevations ranged between 43.56 and 51.54 feet (NAVD88) and estimated groundwater flow direction was generally consistent with historical observations (west) (BESC 2019e). In 2019, groundwater elevations ranged between 46.37 and 53.33 feet (NAVD88) and estimated direction of groundwater flow was to the west, consistent with 2017 observations and generally consistent with historical observations prior to 2017 (BESC 2019a).

6.2.2 KGF Pad 34-31 Previous Investigations and Monitoring Activities

Site investigations and groundwater monitoring have been conducted at KGF Pad 34-31 in association with the eastern reserve pit since the 1980s. UOCC initiated cleanup of the reserve pit in 1992, resulting in 12,000 cy of soil removed and disposed offsite. Impacted soil was left in place along the western wall due to existing active gas wells and infrastructure (SLR 2014b).

In 1999, an NGC hydrocarbon sheen and odor were observed in the well cellar at the WD-1 Water Injection Building. Additionally, a pipeline release was discovered beneath the Jump-Over No. 6 building in the same year. Monitoring wells were installed to investigate the nature and extent of impacts to soil and groundwater.

In 2000, one downgradient well location contained DRO concentrations in soil and groundwater exceeding ADEC Table C groundwater cleanup levels. A subsequent soil and groundwater assessment performed in September

2000 included the installation of eight monitoring wells and showed detected concentrations of DRO in soil and groundwater exceeding ADEC cleanup levels in three monitoring well locations. These results suggested that historical releases from the WD-1 well cellar, the Jump-Over No. 6 building, and a dry well associated with the Wastewater Building Housing Tanks 2 and 3 may be the source of the impacted soil and groundwater. Monitoring well MW-3, located near the Jump-Over No. 6 Building, was abandoned because it was not providing necessary data for plume delineation (SLR 2014b).

Natural attenuation parameters were collected between 2000 and 2003. Groundwater monitoring in 2002 found two monitoring wells containing LNAPL, and absorbent socks were installed; however, later the same year LNAPL was found in only one of the wells. In 2004, in concurrence with ADEC, it was determined that aerobic and anaerobic processes were occurring, and hydrocarbons were naturally attenuating. Collection of natural attenuation parameters was terminated in 2004, and annual groundwater monitoring was conducted in 2005 and 2006 (SLR 2014b).

In 2007, additional soil borings and monitoring wells were installed at KGF Pad 34-31 both on and off the pad to assess potential impacts from the former reserve pit. Areas of concern identified following the 2007 assessment were related to historical operations at KGF Pad 34-31, including produced fluid and diesel fuel impacts to the pad surface and subsurface. Only one contaminant, DRO, has been detected at concentrations exceeding the ADEC Table C groundwater cleanup levels. Annual monitoring conducted between 2010 and 2015 reported similar observations, with only DRO exceeding ADEC Table C groundwater cleanup levels. LNAPL was observed in one well in 2010 and 2011 (SLR 2014b), but was not observed during quarterly monitoring in 2007 and 2008 and has not been observed since (SLR 2014b, 2015b; BESC 2016e). Following groundwater monitoring in 2011, ADEC recommended evaluating the soundness and value of three monitoring wells (MW-A, MW-C, and MW-E); it was suggested that the wells be considered for decommissioning.

In 2017, monitoring wells MW-1, MW-2, MW-4, MW-6, MW-7, MW-8, MW-9, MW-10, MW-11, and MW-12 were sampled for DRO, petroleum-related VOCs (including BTEX), and PAH at KGF Pad 34-31. Concentrations of DRO in monitoring wells MW-1, MW-4, MW-7, and MW-9 exceeded ADEC Table C groundwater cleanup levels. Results for all other analytes were either non-detect or below ADEC Table C groundwater cleanup levels. Several results for PAH analytes in well MW-9 were non-detect with limits of quantitation exceeding ADEC Table C groundwater cleanup levels; dilution factors required during analysis for high concentrations of DRO in the sample caused these limits to be elevated. While purging monitoring well MW-11, purge water was initially observed as opaque reddish-orange with constant air bubbles, silt, and fine sand particles; however, the water cleared after approximately 4 gallons were purged. All wells were resurveyed in October 2017. Monitoring wells MW-C and MW-E were decommissioned. Monitoring wells MW-A and MW-3 could not be located during the 2017 sampling event and were assumed to have previously been decommissioned or destroyed (BESC 2019e).

In 2019, monitoring wells MW-1, MW-2, MW-4, MW-5, MW-6, MW-7, MW-8, MW-9, MW-10, MW-11, MW-12, MW-15, and MW-16 were sampled for DRO, petroleum-related VOCs (including BTEX), and PAH. Concentrations of DRO were equal to or exceeded the ADEC Table C groundwater cleanup level in monitoring wells MW-1, MW-7, MW-8, MW-9, and MW-10. Results for all other analytes were either non-detect or were detected at concentrations below ADEC Table C groundwater cleanup levels. Contaminant concentrations were observed to be generally consistent with historical observations. During monitoring well inspection and maintenance activities, some heaving was observed at MW-6 and MW-16, which did not appear to be affecting the performance of the wells. All other wells were in generally good condition and require little maintenance (BESC 2019a).

6.2.3 KGF Pad 34-31 2021 Monitoring Well Inspections and Maintenance

All KGF Pad 34-31 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 6-3 includes a well maintenance summary for KGF Pad 34-31.

Table 6-3: KGF Pad 34-31 Well Maintenance Summary

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
MW-1	Good				19.88	2”	Slight to moderate HC odor in 2019.
MW-2	Good				19.49	2”	
MW-4	Good				19.43	4”	Light HC odor in 2019.
MW-5	Fair				19.52	4”	Needs monument cap.
MW-6	Good				18.82	4”	Concrete base cracked; no impact to well.
MW-7	Good				18.52	4”	
MW-8	Good				18.86	2”	
MW-9	Good				19.8	4”	Moderate HC odor in 2019.
MW-10	Good				20.04	4”	Slight HC odor in 2019.
MW-11	Good				20.4	4”	Obstruction observed at ~25’ btoc in 2017; none observed in 2019.
MW-12	Good				16.89	2”	
MW-13	Good				12.86	2”	
MW-14	Good				13.3	2”	
MW-15	Good				21.28	2”	
MW-16	Fair	X			17.74	2”	Concrete heaved ~0.33’ above ground surface.
MW-17	Good				14.49	2”	

Notes:
For definitions, see the Acronyms and Abbreviations section.
[1] All wells Schedule 40 PVC unless otherwise indicated.

6.2.4 KGF Pad 34-31 2021 Groundwater Monitoring Activities

KGF Pad 34-31 groundwater wells are monitored on a biennial and a 4-year schedule. All viable wells are gauged during each sampling event. The planned field activities for the 2021 groundwater monitoring at KGF Pad 34-31 are summarized below:

- The vegetation at and surrounding KGF Pad 34-31 will be visually assessed for potential offsite migration of contaminants. The visual assessment will focus on signs of stressed vegetation and/or impacts to wetlands and surface water.
- Gauge groundwater levels in all monitoring wells within a 2-hour period in order to determine groundwater elevation and flow direction.
- MW-1, MW-2, MW-4, MW-6, MW-7, MW-8, MW-9, MW-10, MW-11, and MW-12: Sample for DRO, 1,2,4-trimethylbenzene, naphthalene, and 1-methylnaphthalene.

- MW-5, MW-15, and MW-16: Sample for DRO, petroleum-related VOCs (including BTEX), and PAH at a frequency of every 4 years. These wells are scheduled to be sampled in 2023.
- Resurvey all KGF Pad 34-31 wells during decommission/installation activities completed under a separate work plan to determine top of casing elevations.

Table 6-4 identifies the KGF Pad 34-31 wells and sample analyses. Monitoring well locations are presented on Figure 8.

Table 6-4: KGF Pad 34-31 Summary of Monitoring Wells and 2021 Analyses

Well ID	Gauge	ANALYSES / METHOD		
		AK102	SW8260C	SW8270D SIM
		DRO	VOCs[1]	PAH[2]
MW-1	X	X	X	X
MW-2	X	X	X	X
MW-4	X	X	X	X
MW-5	X			
MW-6	X	X	X	X
MW-7	X	X	X	X
MW-8	X	X	X	X
MW-9	X	X	X	X
MW-10	X	X	X	X
MW-11	X	X	X	X
MW-12	X	X	X	X
MW-13	X			
MW-14	X			
MW-15	X			
MW-16	X			
MW-17	X			

Notes:
For definitions, see the Acronyms and Abbreviations section.
[1] Petroleum-related VOC analytes reduced in 2019 to include only 1,2,4 trimethylbenzene.
[2] PAH analytes reduced in 2019 to include only naphthalene and 1-methylnaphthalene.

6.3 KGF Pad 41-7

KGF Pad 41-7 is located centrally within KGF and approximately 1 mile east of KGF Pad 14-6 as shown on Figure 4 (Appendix A). The KGF Pad 41-7 property lies within Salamatof Native Association, Inc. land on Kenai Peninsula Borough Tax Parcel number 13103014. KGF Pad 41-7 was constructed in the late 1950s by UOCC. Several buildings and gas recovery transmission infrastructure are present on the pad, including Reboiler, Meter, Contractor, and Compressor buildings clustered in the southern half of KGF Pad 41-7. Marathon acquired the KGF facilities in 1994. Hilcorp took over operations of KGF Pad 41-7 in 2013 and is the current operator (SLR 2015b).

6.3.1 KGF Pad 41-7 Geology and Hydrogeology

KGF Pad 41-7 is a 3- to 4-foot gravel pad placed over native tundra, wetland, and spruce bog terrain in 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. Beneath the organic soil layer lies a thin layer of fine-grained alluvium, then interbedded sand and sandy gravel to at least 20 feet bgs (SLR 2015b).

Groundwater flow at KGF Pad 41-7 has historically been observed to vary from west-northwest on the west side of the pad and east-northeast on the east side of the pad during summer/fall sampling events (SLR 2015b). In 2017, groundwater elevations ranged from 66.30 to 68.96 feet (NAVD88) and estimated groundwater flow direction was generally to the west with some mounding under the western portion of the pad (BESC 2019e). In 2019, groundwater elevations at KGF Pad 41-7 ranged between 65.71 and 66.43 feet (NAVD88) and estimated direction of groundwater flow was to the southwest, which is a slight variation from historical observations.

6.3.2 KGF Pad 41-7 Previous Investigations and Monitoring Activities

A release from a fluid discharge line spurred the beginning of site investigations and assessments of soil and groundwater at KGF Pad 41-7 in 1999. Five hand-driven well points were installed near the observed release, and results from soil and groundwater samples confirmed produced water impacts were present. Contaminant concentrations in groundwater exceeded the applicable ADEC Table C groundwater cleanup levels. KGF Pad 41-7 was expanded to the south in 2003, covering up this area with gravel. The well points were abandoned (SLR 2015b).

Following a 2005 expansion of the pad, site assessment activities included installation of six soil borings and monitoring wells near the edge of the pad. Soil and groundwater sampling in 2005 and 2006 found petrogenic contaminants exceeding ADEC cleanup levels in one soil boring and one different monitoring well (SLR 2015b).

In the winter of 2007, seven additional monitoring wells were installed in the wetlands surrounding KGF Pad 41-7. Twelve more monitoring wells were installed on the pad during the summer of 2007. Groundwater sampling indicated that natural attenuation was occurring beneath the pad. Areas of concern on the pad related to releases of produced fluid and diesel fuel were identified. A dissolved-phase plume was identified on the east side of the pad (SLR 2015b).

Groundwater monitoring conducted in 2008 included the decommissioning of MW-1, MW-6, MW-7, MW-8, and MW-18. LNAPL, from NGC, was observed in the western area of the pad and was surrounded by a dissolved-phase DRO plume. DRO-impacted groundwater was also observed around MW-16, likely associated with drilling muds incorporated into the pad. Analytical results confirmed that contaminants were not migrating off the pad to the north or south (SLR 2015b).

Additional site assessment activities were conducted in 2009. Eight soil borings were advanced and completed as monitoring wells along the northern edge of the pad. Soil within a fibrous peat layer was detected containing DRO and benzene concentrations greater than ADEC cleanup levels and was not fully delineated. Groundwater analytical samples indicated groundwater was not impacted (SLR 2015b).

Groundwater monitoring in 2010 found the dissolved-phase DRO plume was not fully delineated, as results for most of the on-pad wells exceeded ADEC Table C groundwater cleanup levels. Fluid level gauging indicated that LNAPL could be migrating to the west, potentially affecting the natural attenuation processes thought to be occurring at the wetland-pad interface (SLR 2015b).

Site monitoring in 2011 included groundwater sampling at 13 wells and collection of six surface water samples. DRO was detected exceeding ADEC Table C groundwater cleanup levels in samples from several on-pad monitoring wells, and it appeared the dissolved-phase plume was expanding to the west. Increased LNAPL thickness was observed in MW-24. No impact to surface water was observed (SLR 2015b).

Eight soil borings were installed and completed as monitoring wells in 2012 to further delineate on-pad hydrocarbon impacts to soil and groundwater. Three source areas were identified: the dissolved-phase DRO plume on the eastern edge of the pad, LNAPL in the southern area of the pad, and dissolved- and separate-phase hydrocarbons in the western area of the pad. DRO, RRO, and benzene were identified as primary contaminants of concern (SLR 2015b).

Annual groundwater monitoring was conducted between 2013 and 2015. Annual monitoring found concentrations of DRO and benzene in groundwater exceeding ADEC Table C groundwater cleanup levels. RRO was added to the analytical suite in 2015, and 2015 monitoring activities also showed concentrations of RRO exceeding the ADEC Table C groundwater cleanup level. LNAPL was observed in MW-24 during each sampling event, though surface water samples indicated no impact to the wetlands west and east of KGF Pad 41-7. Remaining concentrations of all other analytes for all wells sampled were less than ADEC Table C groundwater cleanup levels or were non-detect (SLR 2015b; BESC 2016b).

In 2017, monitoring wells MW-15, MW-16R, MW-19, MW-20, MW-21R, MW-25, MW-29, MW-33, and MW-37 were sampled for DRO, petroleum-related VOCs (including BTEX), and PAH at KGF Pad 41-7. Concentrations of DRO in wells MW-20 and MW-33 (1,720 µg/L and 1,950 µg/L, respectively) exceeded the ADEC Table C groundwater cleanup level of 1,500 µg/L. Results for all other analytes were either non-detect or below ADEC Table C groundwater cleanup levels. Drawdown occurring in well MW-33 resulted in insufficient water column height to deploy a HydraSleeve; all samples were collected using a peristaltic pump set at 120 mL/min. Six monitoring wells scheduled for sampling (MW-22R, MW-24, MW-28, MW-32, MW-35, and MW-36) were not located and were assumed to either have been previously decommissioned or destroyed. Product was detected in monitoring wells MW-23R and MW-24 at the time of gauging, and the wells were not sampled. Absorbent socks were placed in the two wells with product. Seven surface water samples were collected and analyzed for BTEX and PAH, and the results were used to calculate TAH and TAqH. No individual analytes were detected in any surface water samples, and TAH and TAqH totals were below 18 AAC 70 water quality standards (ADEC 2018b), indicating no off-pad contaminant migration. Monitoring wells MW-30 and MW-34 were decommissioned in 2017. Monitoring well MW-4 was scheduled for decommissioning but was unreachable by the drilling unit, and monitoring well MW-24 was scheduled for decommissioning but was postponed until further investigation could occur (BESC 2019e).

In 2019, monitoring wells MW-15, MW-16R, MW-19, MW-20, MW-21R, MW-23R, MW-25, MW-27, MW-29, MW-31, MW-33, and MW-37 were sampled for DRO, petroleum-related VOCs (including BTEX), and PAH. Wells MW-23R, MW-27, and MW-31 were also sampled for GRO and RRO. Well MW-23R previously contained LNAPL but none was detected in 2019 and the well was sampled for the first time since 2013; however, it was purged and sampled using a peristaltic pump because an obstruction (suspected bend in the PVC riser) prevented the use of a bladder pump. Volatile samples were collected using the peristaltic pump by detaching tubing prior to paddles and decanting from tubing. Well MW-24 was not sampled due to detected LNAPL; less than 1 gallon of product was removed. Well MW-36 was not located in 2017; however, was located during 2019 activities and was not sampled due to its poor condition. Concentrations of DRO, RRO, 1,2,4-trimethylbenzene, benzene, ethylbenzene, naphthalene, and 1-methylnaphthalene in well MW-23R exceeded the ADEC Table C groundwater cleanup levels, which was sampled for the first time since 2013. Concentrations of DRO and benzene in well MW-33 exceeded ADEC Table C groundwater cleanup levels, and the DRO result for well MW-19 was equal to the ADEC Table C groundwater cleanup level (1,500 µg/L). Results for all other analytes were either non-detect or were detected at concentrations below ADEC Table C groundwater cleanup levels. Contaminant concentrations were observed to be generally consistent with historical observations, with the exception of one DRO concentration in MW-20 detected below ADEC Table C groundwater cleanup levels for the first time since June 2010, and two elevated concentrations of various analytes in MW-23R, which was sampled for the first time since 2013. Seven surface water samples were collected and analyzed for BTEX and PAH, and the results were used to calculate TAH and TAqH. All results for individual BTEX and PAH analytes, and calculated values for TAH and TAqH were below 18 AAC 70 water quality standards (ADEC 2018b), indicating no off-pad contaminant migration. During monitoring well inspection and maintenance activities, heaving was observed in monitoring wells MW-17, MW-24, and MW-25; PVC riser was cut down on these wells. Approximately 2.27 feet of riser had snapped off before gauging MW-27, and well MW-20 had a missing collar. Well MW-36 was located during 2019 activities (not located in 2017) and was observed to be in poor condition. MW-32 was not located and assumed to have been previously decommissioned or destroyed. All other wells were in generally good condition and required little maintenance (BESC 2019a).

In 2020, monitoring wells MW-2, MW-3, MW-4, MW-5, MW-10, MW-11, MW-13, MW-24, and two unnamed wells (one north of MW-3 and one east of MW-2) were decommissioned during the winter. These particular wells, with the exception of MW-24, were inaccessible during the summer months due to their location in the wetland; thus, were only able to be decommissioned during winter months. Well MW-24 was decommissioned to seal off any potential for communication between the deep water-bearing interval and the shallow water-bearing interval. Additionally, well MW-40 was installed slightly north and east of planned location to avoid utilities while still providing safe access for future sampling.

6.3.3 KGF Pad 41-7 2021 Monitoring Well Inspections and Maintenance

All KGF Pad 41-7 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 6-5 includes a well maintenance summary for KGF Pad 41-7.

Table 6-5: KGF Pad 41-7 Well Maintenance Summary

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
MW-2	Decommissioned in 2020.						
MW-3	Decommissioned in 2020.						
MW-4	Decommissioned in 2020.						
MW-5	Decommissioned in 2020.						
MW-10	Decommissioned in 2020.						
MW-11	Decommissioned in 2020.						
MW-13	Decommissioned in 2020.						
MW-15	Good				6.18	2”	
MW-16R	Good				5.05	2”	
MW-17	Good	X			6.22	-	Slight to moderate HC odor in 2019. Sheen on probe. Cut ~0.27’ PVC.
MW-19	Good				4.73	2”	
MW-20	Fair				5.23	2”	Missing collar.
MW-21R	Good				7.06	2”	No monument or well cap.

Table 6 5: KGF Pad 41-7 Well Maintenance Summary (continued)

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
MW-23R	Poor		X	X	2.45	2”	Snapped riser at ground surface. Riser bent bgs; evidence of gravel and debris in well. Scheduled for decommission.
MW-23R2	Replacement well for MW-23 to be installed.						
MW-24	Decommissioned in 2020.						
MW-25	Good	X			6.06	2”	Damaged in May 2021 (vehicle strike). Scheduled for decommission.
MW-25R	Replacement well for MW-25 to be installed.						
MW-27	Poor				2.62	2”	~2.27’ of riser snapped.
MW-27R	Replacement well for MW-27 to be installed.						
MW-29	Good				7.71	2”	No monument or cap.
MW-31	Good				2.76	2”	No monument or cap. Slight HC odor in 2021.
MW-32	Assumed destroyed or decommissioned in 2020.						
MW-33	Fair	X			2.15	2”	Rusted lid; difficult access. No lock.
MW-36	Poor				1.98	-	Located in 2019. Aboveground monument flush with ground surface. Soft hit at total depth in 2019, severe damage to monument lid, and area between well and monument filled with soil, gravel, and bentonite.
MW-36R	Replacement well for MW-36 to be installed.						
MW-37	Good				5.86	2”	No monument or lock.
MW-38	Additional well to be installed near MW-24; accessing shallow water-bearing interval.						
MW-39	Additional well to be installed near MW-33, accessing deeper water-bearing interval.						
MW-40	-				-	-	Installed in 2020. Replacement well for MW-5. Placement of well helps identify off-pad contaminant migration, if any.

Notes:
For definitions, see the Acronyms and Abbreviations section.
- Unknown or not determined
[1] All wells Schedule 40 PVC unless otherwise indicated.
[2] Shaded rows indicate wells previously destroyed or decommissioned, to be decommissioned or replaced, or not yet installed. Wells to be decommissioned and/or installed are addressed under a separate work plan.

6.3.4 KGF Pad 41-7 2021 Groundwater Monitoring Activities

KGF Pad 41-7 groundwater wells are monitored on a biennial schedule. All viable wells are gauged during each sampling event. Additionally, seven surface water samples are collected biennially from the historical locations

(Figure 9). The planned field activities for the 2021 groundwater monitoring at KGF Pad 41-7 are summarized below:

- The vegetation at and surrounding KGF Pad 41-7 will be visually assessed for potential offsite migration of contaminants. The visual assessment will focus on signs of stressed vegetation and/or impacts to wetlands and surface water.
- Gauge groundwater levels in all monitoring wells within a 2-hour period in order to determine groundwater elevation and flow direction.
- Collect surface water samples from seven locations for BTEX and PAH to calculate TAH and TAqH and verify contamination is not migrating off-pad and/or to surface water.
- MW-40: Re-develop well. This well was installed during winter 2020 as a replacement for wetland well MW-5 (decommissioned 2020). Sample for DRO, petroleum-related VOCs (including BTEX), and PAH.
- MW-15, MW-16R, MW-19, MW-20, MW-21R, MW-23R, MW-25, MW-29, MW-33, MW-36, and MW-37: Sample for DRO, 1,2,4-trimethylbenzene, benzene, ethylbenzene, naphthalene, xylenes, and 1-methylnaphthalene.
- MW-27 and MW-31: Sample for GRO, DRO, RRO, 1,2,4-trimethylbenzene, benzene, ethylbenzene, naphthalene, xylenes, and 1-methylnaphthalene. These wells were incorporated into the groundwater sampling program in 2019 based on their proximity to wells MW-23R and MW-24 (both contained LNAPL in 2017).
- MW-25: Investigate and assess condition for damage. Sample per groundwater program if in adequate condition; otherwise, replace (decommission/installation activities completed under a separate work plan).
- MW-23R, MW-27, MW-36: Decommission and replace (decommission/installation activities completed under a separate work plan).
- MW-38 and MW-39: Install (decommission/installation activities completed under a separate work plan). Well MW-38 will be near decommissioned well MW-24 to access shallow water-bearing interval. Well MW-39 will be near existing well MW-33 to access the deep water-bearing interval.
- MW-32: Removed from sampling program and was not positively identified in 2019. If found, decommission during decommission/installation activities completed under a separate work plan.
- MW-19, MW-23R (or replacement), MW-27 (or replacement), MW-29, and MW-31: Install bollards to protect wells (no protective metal casings) during decommission/installation activities completed under a separate work plan.
- Resurvey all KGF Pad 41-7 wells during decommission/installation activities completed under a separate work plan to determine top of casing elevations.

Table 6-6 identifies the KGF Pad 41-7 wells and sample analyses. Monitoring well and surface water sample locations are presented on Figure 9.

Table 6-6: KGF Pad 41-7 Summary of Monitoring Wells and 2021 Analyses

Well ID	Gauge	ANALYSES / METHOD						
		AK101	AK102	AK103	SW8260C		SW8270D SIM	
		GRO	DRO	RRO	VOCs[1]	Select VOCs[2]	PAH[1]	Select PAH[3]
MW-15	X		X			X		X
MW-16R	X		X			X		X
MW-17	X							

Table 6-6: KGF 41-7 Summary of Monitoring Wells and Analyses (continued)

Well ID	Gauge	ANALYSES / METHOD						
		AK101	AK102	AK103	SW8260C		SW8270D SIM	
		GRO	DRO	RRO	VOCs[1]	Select VOCs[2]	PAH[1]	Select PAH[3]
MW-19	X		X			X		X
MW-20	X		X			X		X
MW-21R	X		X			X		X
MW-23R	X		X			X		X
MW-25	X		X			X		X
MW-27	X	X	X	X		X		X
MW-29	X		X			X		X
MW-31	X	X	X	X		X		X
MW-33	X		X			X		X
MW-36	X		X			X		X
MW-37	X		X			X		X
MW-40	X		X		X		X	
Surface Water (x7)	-					BTEX	X	

Notes:
For definitions, see the Acronyms and Abbreviations section.
- Not applicable
[1] Full list analysis. Petroleum-related VOCs include BTEX.
[2] Petroleum-related VOC analytes reduced in 2019 to include only 1,2,4-trimethylbenzene, benzene, ethylbenzene, and xylenes.
[3] PAH analytes reduced in 2019 to include only naphthalene and 1-methylnaphthalene.

6.4 KGF Pad 41-18

KGF Pad 41-18 is in the southern section of the KGF and approximately 1 mile south of KGF Pad 41-7 (Figure 2). The KGF Pad 41-18 property lies within Cook Inlet Region, Inc. Tax Parcel number 13108022. KGF Pad 41-18 has been used for oil and gas exploration and production since its construction by UOCC in 1971. In 1994, Marathon assumed operation of the gas field, and Hilcorp assumed operation of KGF Pad 41-18 in 2013. The pad includes multiple gas wellheads, groundwater monitoring wells, and several current and former operations buildings including a Water Well Building, Equipment Building, Meter Building, Wastewater Building, and Grind and Inject Building (SLR 2014d).

6.4.1 KGF Pad 41-18 Geology and Hydrogeology

KGF Pad 41-18 is a gravel pad built in the spruce bog terrain of the Kenai lowlands. The Kenai lowlands consist of topographically flat, discontinuous wetlands with organic soil from the surface to approximately 6 feet bgs. KGF Pad 41-18 was constructed by placing 3-4 feet of gravel on top of the organic soil. Beneath the organic soil layer lies a thin layer of fine-grained alluvium, then interbedded sand and sandy gravel to at least 20 feet bgs (SLR 2014d).

Groundwater at KGF Pad 41-18 has historically been observed to flow to the northwest during summer/fall sampling events (SLR 2014d). In 2017, groundwater elevations ranged between 67.15 and 70.00 feet (NAVD88) and estimated groundwater flow direction was northwest (BESC 2019e). In 2019, groundwater elevations ranged between 66.56 and 69.28 feet (NAVD88) and estimated groundwater flow direction was to the northwest, consistent with historical observations.

6.4.2 KGF Pad 41-18 Previous Investigations and Monitoring Activities

Hydrocarbon staining and liquid were observed inside a well cellar at KGF Pad 41-18 in 1999. A shallow aquifer groundwater investigation conducted in 2000 included the installation of a monitoring well, collection of soil and groundwater samples, and collection of samples from within the well cellar. Analytical results indicated that DRO and benzene concentrations exceeded the ADEC Method Two soil cleanup levels in the subsurface. Analytical groundwater results indicated that DRO and RRO were present but at concentrations less than ADEC Table C groundwater cleanup levels. Liquid within the well cellar contained DRO concentrations above the ADEC Table C groundwater cleanup level. Groundwater monitoring has been conducted on a regular basis since 2000. An additional assessment in 2001 included installation of eight soil borings and three monitoring wells. Analytical results confirmed subsurface soil and groundwater were impacted by petroleum hydrocarbons near the former Wastewater Building (SLR 2014d).

Site characterization and assessment activities in 2008 included installation of nine soil borings, completed as groundwater monitoring wells, four of which were off the pad. Analytical samples were assessed for biogenic contribution to petroleum hydrocarbon results, as the site is surrounded by tundra peat. Analytical results for all four analytical soil samples from off-pad exceeded the ADEC Method Two soil cleanup level for DRO; however, further analysis of gas chromatograms indicated the source of the elevated DRO concentrations was biogenic, not petrogenic. On-pad soil samples indicated DRO-impacted soil at MW-11 (SLR 2014d).

Groundwater monitoring was conducted twice in 2008; groundwater from all but two of the on-pad wells exhibited concentrations of DRO exceeding the ADEC Table C groundwater cleanup level. DRO was detected in groundwater off-pad but at concentrations less than the ADEC Table C groundwater cleanup level. Gas chromatograms from the off-pad samples indicated elevated DRO concentrations remained biogenic. Analytical results for surface water samples downgradient of the pad did not exceed surface water quality criteria for petroleum contaminants (SLR 2014d).

Two soil borings were advanced in 2009 at the northern edge of the pad and were completed as monitoring wells. DRO concentrations exceeded the ADEC Method Two soil cleanup level in one borehole, and benzene concentrations exceeded ADEC Method Two soil cleanup levels in both boreholes. Groundwater samples from all monitoring wells at KGF Pad 41-18 indicated two areas of DRO-impacted groundwater: adjacent to the former Wastewater Building, and along the north and west edges of the pad (SLR 2014d).

Annual groundwater monitoring conducted between 2011 and 2015 found similar results to previous monitoring events, with DRO-impacted groundwater in monitoring wells near the former Wastewater Building, as well as in monitoring wells on the north and west sides of the pad. Results from surface water samples collected from downgradient locations off the pad did not exceed surface water quality criteria (SLR 2015c; BESC 2016d).

In 2017, monitoring wells MW-3R, MW-4, MW-9, MW-11R, MW-15, MW-16, and MW-17 were sampled for DRO, petroleum-related VOCs (including BTEX), and PAH at KGF Pad 41-7. Groundwater monitoring results indicated exceedances of ADEC Table C groundwater cleanup levels for DRO and naphthalene. Monitoring wells MW-3R, MW-11R, MW-16, and MW-17 were observed to have inner diameters of 1.5 inches or less and samples were collected using a peristaltic pump at reduced flow rate, typically under 200 mL/min. Monitoring well MW-3R was purged dry and had poor recharge, possibly due to bentonite inside the screen. Five surface water samples were collected and analyzed for BTEX and PAH to calculate TAH and TAqH. The analytical result for toluene and the calculated TAH value of 13.4 µg/L in one surface water sample location (SW-5) exceeded the ADEC 18 AAC 70 water quality standard of 10 µg/L (ADEC 2018b). All other individual analytical results and calculated values for

TAH and TAqH were below the ADEC water quality standards. Monitoring well MW-13 was decommissioned. Wells MW-3R, MW-17, and MW-18 showed signs of bentonite infiltration during sampling, possibly indicating cracked or sheared risers (BESC 2019e).

In 2019, monitoring wells MW-2, MW-4, MW-9, MW-11R, MW-12, MW-14, MW-15, MW-16, MW-17, and MW-19 were sampled for DRO, petroleum-related VOCs (including BTEX), and PAH. Monitoring wells MW-11R, MW-16, MW-17, and MW-19 were sampled using a peristaltic pump due to inner diameters of 1.5 inches or less. Volatile samples were collected by detaching the tubing prior to the paddles and decanting from the tubing. Physical properties of the groundwater at MW-9 (thin, soapy water with low meniscus) prevented elimination of headspace in the sample glassware. Bentonite infiltration was observed in wells MW-3R, MW-8R, MW-17, and MW-18, preventing sampling in wells MW-3R and MW-18. Concentrations of DRO in wells MW-9 and MW-15 and naphthalene in well MW-9 exceeded ADEC Table C groundwater cleanup levels. Results for all other analytes were either non-detect or detected at concentrations below ADEC Table C groundwater cleanup levels. Contaminant concentrations were observed to be generally consistent with historical observations, except for elevated naphthalene concentrations in MW-9. Surface water samples were collected at five locations and analyzed for BTEX and PAH. TAH/TAqH values were calculated from the results. Sample results for toluene, benzene, 1-methylnaphthalene, 2-methylnaphthalene, acenaphthene, fluorene, naphthalene, and phenanthrene were detected at one or more surface water locations; all other results were non-detect. Calculated TAH and TAqH values for all surface water locations were below 18 AAC 70 water quality standards (ADEC 2018b). During monitoring well inspection and maintenance activities, heaving was observed in MW-15, and the PVC riser was cut down. Wells MW-11R, MW-16, MW-17, and MW-19 did not have protective monuments, and well MW-14 had a broken collar. All other wells were in generally good condition and require little maintenance (BESC 2019a).

In 2020, monitoring wells MW-5 and MW-7 were decommissioned during the winter. These particular wells were inaccessible during the summer months due to their location in the wetland; thus, were only able to be decommissioned during winter months. MW-6 was scheduled for decommission; however, was not located and assumed destroyed. It is likely that the MW-6 casing was heaved up and out.

6.4.3 KGF Pad 41-18 2021 Monitoring Well Inspections and Maintenance

All KGF Pad 41-18 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 6-7 includes a well maintenance summary for KGF Pad 41-18.

Table 6-7: KGF Pad 41-18 Well Maintenance Summary

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
MW-2	Fair	X			7.9	4”	Collar held in place.
MW-3R	Poor				7.2	1.5”	No monument. Evidence of bentonite infiltration at bottom; prevented sampling in 2019.
MW-3R2	Replacement well for MW-3R to be installed.						

Table 6 7: KGF Pad 41-18 Well Maintenance Summary (continued)

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
MW-4	Good	X			8.62	4”	Casing heaved up to collar, but collar held in place.
MW-5	Decommissioned in 2020.						
MW-6	Not located in 2020. Assumed destroyed or decommissioned.						
MW-7	Decommissioned in 2020.						
MW-8R	Good				5.05	1.5”	No protective monument. Bentonite infiltration.
MW-9	Good				7.55	2”	
MW-10	Fair				7.92	-	Concrete base cracked.
MW-11R	Good				7.95	1.5”	No protective monument.
MW-12	Good				7.63	2”	
MW-14	Good				7.55	2”	Broken collar.
MW-15	Good	X			7.93	2”	Riser cut ~2”.
MW-16	Good				7.71	1.5”	No protective monument.
MW-17	Good				6.79	1.5”	Bentonite Infiltration. No protective monument.
MW-17R	Replacement well for MW-17 to be installed.						
MW-18	Poor				6.65	1.5”	Bentonite Infiltration.
MW-18R	Replacement well for MW-18 to be installed.						
MW-19	Good				6.91	1.5”	No protective monument.

Notes:
For definitions, see the Acronyms and Abbreviations section.
- Unknown or not determined
1 All wells Schedule 40 PVC unless otherwise indicated.
2 Shaded rows indicate wells previously destroyed or decommissioned, to be decommissioned or replaced, or not yet installed. Wells to be decommissioned and installed are addressed under a separate work plan.

6.4.4 KGF Pad 41-18 2021 Groundwater Monitoring Activities

KGF Pad 41-18 groundwater wells are monitored on a biennial and a 4-year schedule. All viable wells are gauged during each sampling event. Additionally, five surface water samples are collected biennially from historical locations (Figure 10). The planned field activities for the 2021 groundwater monitoring at KGF Pad 41-18 are summarized below:

- The vegetation at and surrounding KGF Pad 41-18 will be visually assessed for potential offsite migration of contaminants. The visual assessment will focus on signs of stressed vegetation and/or impacts to wetlands and surface water.
- Gauge groundwater levels in all monitoring wells within a 2-hour period in order to determine groundwater elevation and flow direction.
- Sample surface water at the same five locations for BTEX and PAH in order to calculate TAH and TAqH and verify that contamination is not migrating off-pad and/or to surface water.
- MW-14 and MW-19: Sample for DRO, petroleum-related VOCs (including BTEX), and PAH to investigate potential contributing factors to the TAH exceedance observed in SW-5 in 2017.

- MW-3R, MW-4, MW-9, MW-11R, MW-15, MW-16, and MW-17: Sample for DRO benzene, naphthalene, and 1-methylnaphthalene.
- MW-2, MW-12, and MW-18: Sample for DRO, benzene, naphthalene, and 1-methylnaphthalene at a frequency of every 4 years. These wells are scheduled to be sampled in 2023.
- MW-3R, MW-17, and MW-18: Decommission and replace (decommission/installation activities completed under a separate work plan). Bentonite infiltration observed in these wells, which may indicate cracked or sheared risers and prevent sampling.
- Resurvey all KGF Pad 41-18 wells during decommission/installation activities completed under a separate work plan to determine top of casing elevations.

Table 6-8 identifies the KGF Pad 41-18 wells and sample analyses. Monitoring well and surface water sample locations are presented on Figure 10.

Table 6-8: KGF Pad 41-18 Summary of Monitoring Wells and 2021 Analyses

Well ID	Gauge	ANALYSES / METHODS				
		AK102	SW8260C		SW8270D SIM	
		DRO	VOCs[1]	Select VOCs[2]	PAH[1]	Select PAH[3]
MW-2	X					
MW-3R	X	X		X		X
MW-4	X	X		X		X
MW-8R	X					
MW-9	X	X		X		X
MW-10	X					
MW-11R	X	X		X		X
MW-12	X					
MW-14	X	X	X		X	
MW-15	X	X		X		X
MW-16	X	X		X		X
MW-17	X	X		X		X
MW-18	X					
MW-19	X	X	X		X	
Surface Water (x5)	-			BTEX	X	

Notes:
For definitions, see the Acronyms and Abbreviations section.
- Not applicable
1 Full list analysis. Petroleum-related VOCs include BTEX.
2 Petroleum-related VOC analytes reduced in 2019 to include only benzene.
3 PAH analytes reduced in 2019 to include only naphthalene and 1-methylnaphthalene.

7.0 REFERENCES

Alaska Department of Environmental Conservation (ADEC). 2020 (November). 18 Alaska Administrative Code (AAC) 75, *Oil and Other Hazardous Substances Pollution Control*.

ADEC. 2018a (September). *Beaver Creek Pad 4 2017 Groundwater Monitoring Report, ADEC Report Comments.* Letter to Hilcorp Alaska, LLC dated 27 September 2018.

ADEC. 2018b (April). 18 AAC 70, *Water Quality Standards*.

ADEC. 2017a (August). *Field Sampling Guidance*. Division of Spill Prevention and Response. Contaminated Sites Program.

ADEC. 2017b (April). Guidelines for Treatment of Non-Detect Values, Data Reduction for Multiple-Detections, and Comparison of Quantitation Limits to Cleanup Values.

ADEC. 2013 (September). *Monitoring Well Guidance*. Division of Spill Prevention and Response. Contaminated Sites Program.

Alaska Oil and Gas Conservation Commission (AOGCC). 1987 (August). Conservation Order No. 231 Re: The Application of Union Oil Company of California requesting issuance of an order establishing pool rules to govern operation of the Cannery Loop Unit. http://doa.alaska.gov/ogc/orders/co/co001_299/co231.htm

Brice Environmental Services Corporation (BESC). 2019a (November). *Final 2019 Groundwater Monitoring Program Report, Kenai Peninsula Sites, Kenai Gas Field.*

BESC. 2019b (October). *Final 2019 Groundwater Monitoring Program Report, Kenai Peninsula Sites, Alaska, Cannery Loop Unit Pad 3.*

BESC. 2019c (October). *Final 2019 Groundwater Monitoring Program Report, Kenai Peninsula Sites, Alaska, Beaver Creek Unit Pad 4.*

BESC. 2019d (March). *Technical Memorandum 2018 Groundwater Monitoring – Beaver Creek Unit Pad 4 North*, Kenai, Alaska.

BESC. 2019e (January). *Draft 2017 Groundwater Monitoring Program Report: Kenai Gas Field Groundwater Monitoring Report, Kenai, Alaska.*

BESC. 2018a (September). Draft 2017 Groundwater Monitoring Program Report: Cannery Loop Unit Pad 3, Kenai, Alaska.

BESC. 2018b (July). 2017 Groundwater Monitoring Program Report: Beaver Creek Unit Pad 4, Kenai, Alaska.

BESC. 2017 (March). 2016 Beaver Creek Pad 4 Release Response, Kenai, Alaska.

BESC. 2016a (July). 2015 Groundwater and Surface Water Monitoring Report – Pad 14-6, Kenai Gas Field, Alaska.

BESC. 2016b (July). 2015 Groundwater and Surface Water Monitoring Report – Pad 41-7, Kenai Gas Field, Alaska.

BESC. 2016c (July). 2015 Groundwater Monitoring Report – Cannery Loop Unit 3, Kenai, Alaska.

BESC. 2016d (May). 2015 Groundwater and Surface Water Monitoring Report – Pad 41-18, Kenai Gas Field, Alaska.

BESC. 2016e (May). *2015 Groundwater Monitoring Report – Pad 34-31*, Kenai Gas Field, Alaska.

BESC. 2016f (January). 2015 Groundwater Monitoring Report – Beaver Creek Production Facility Pad 4, Kenai, Alaska.

BESC. 2015 (September). Hilcorp Groundwater Optimization Summary, Kenai, Alaska.

Oasis Environmental Inc. (Oasis). 2012 (April). Beaver Creek Production Facility--Pad 4: 2010 Annual Groundwater Monitoring Report, Kenai, Alaska.

Oasis. 2008 (April). Site Assessment and Remedial Evaluation Report, Beaver Creek Pad 4, Kenai Alaska.

Oasis. 2001 (January). Additional Source Area Assessment, Well Abandonment, and Annual Groundwater Monitoring – Beaver Creek Production Facility, Pad BC-4, Kenai Peninsula, Alaska.

SLR International Corporation (SLR). 2015a (June). 2014 Groundwater and Surface Water Monitoring Report, Kenai Gas Field Pad 14-6, Kenai, Alaska.

SLR. 2015b (June). 2014 Groundwater and Surface Water Monitoring Report, Kenai Gas Field Pad 41-7, Kenai, Alaska.

SLR. 2015c (June). 2014 Groundwater and Surface Water Monitoring Report, Kenai Gas Field Pad 41-18, Kenai, Alaska.

SLR. 2015d (June). 2014 Groundwater Monitoring Report, Kenai Gas Field Pad 34-31, Kenai, Alaska.

SLR. 2014a (November). 2013 Groundwater and Surface Water Monitoring Report, Kenai Gas Field Pad 14-6, Kenai, Alaska.

SLR. 2014b (November). 2013 Groundwater and Surface Water Monitoring Report, Kenai Gas Field Pad 34-31, Kenai, Alaska.

SLR. 2014c (November). 2013 Groundwater and Surface Water Monitoring Report, Kenai Gas Field Pad 41-7, Kenai, Alaska.

SLR. 2014d (November). 2013 Groundwater and Surface Water Monitoring Report, Kenai Gas Field Pad 41-18, Kenai, Alaska.

SLR. 2014e (September). 2013 Groundwater Monitoring Report, Cannery Loop Unit 3, Kenai, Alaska.

SLR. 2014f (July). 2013 Groundwater Monitoring Report, Beaver Creek Production Facility Pad 4, Kenai, Alaska.

U.S. Environmental Protection Agency (EPA). 2017 (September). Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells. EQASOP-GW4.

Weston Solutions (Weston). 2012 (November). 2012 Groundwater Monitoring Report, Kenai Gas Field Pad 34-31, Kenai, Alaska.

APPENDIX A:
FIGURES

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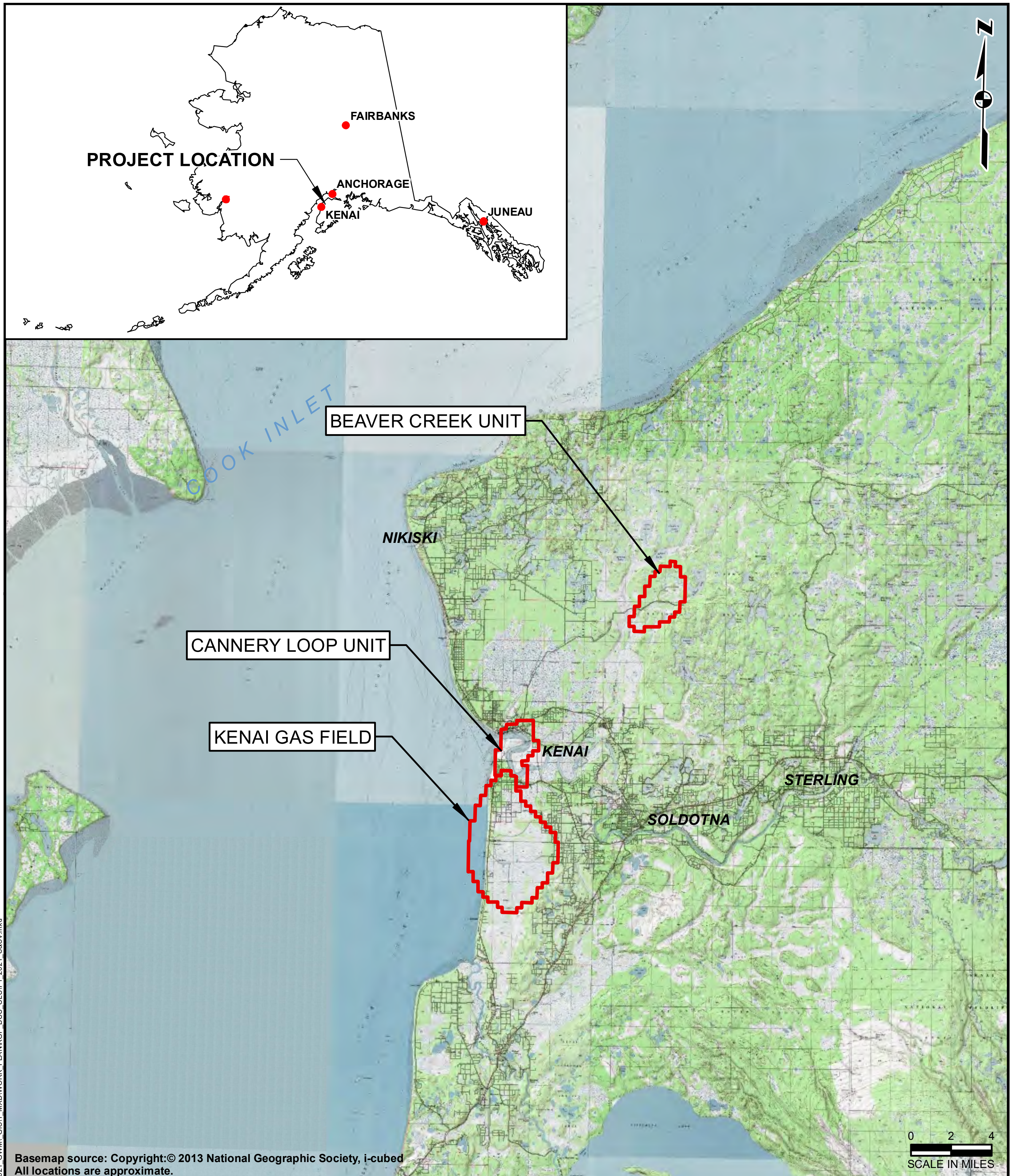

Basemap source: Copyright:© 2013 National Geographic Society, i-cubed
All locations are approximate.

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Anchorage, AK 99503

2021 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: 5/25/2021
PROJECT No.: 760101
DRAWN: JC

FIGURE: 1

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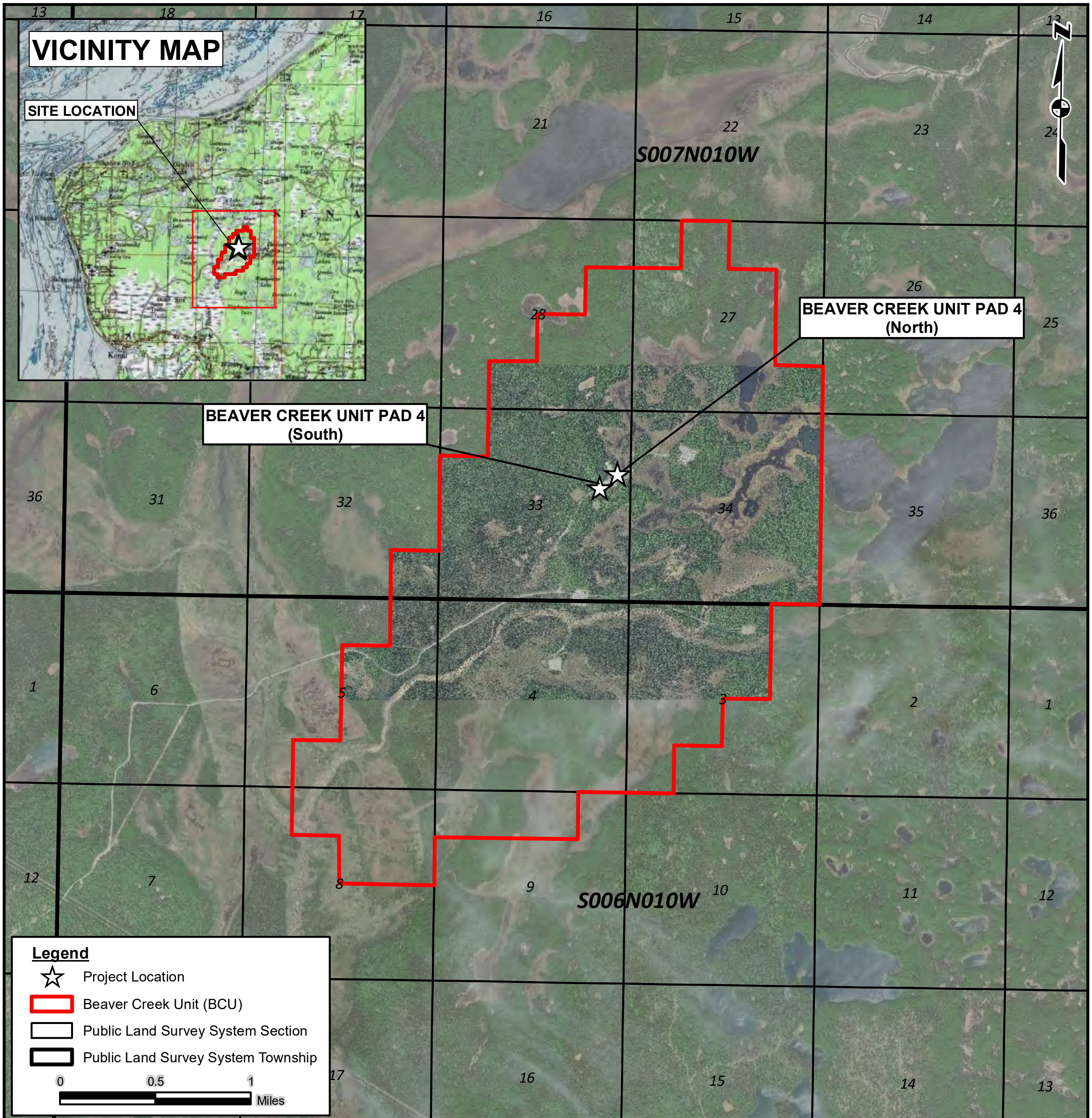

Notes:

1. For conceptual purposes only. All locations are approximate.
2. BCU boundary digitized from map obtained through BLM Alaska Cook Inlet Oil & Gas Leasing.
3. Low-resolution aerial imagery and PLSS data obtained from Kenai Peninsula Borough GIS layer files.
4. Aerial imagery within unit boundaries acquired from Quantum Spatial Inc. Imagery was acquired on May 31, 2017.
5. Inset map credits: Copyright:© 2013 National Geographic Society, i-cubed

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Anchorage, AK 99503

2021 GROUNDWATER MONITORING PROGRAM WORK PLAN
BEAVER CREEK UNIT PAD 4, CANNERY LOOP UNIT PAD 3, KENAI GAS FIELD
KENAI PENINSULA, ALASKA

BEAVER CREEK UNIT SITE MAP

DATE: 5/25/2021
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FIGURE: 2

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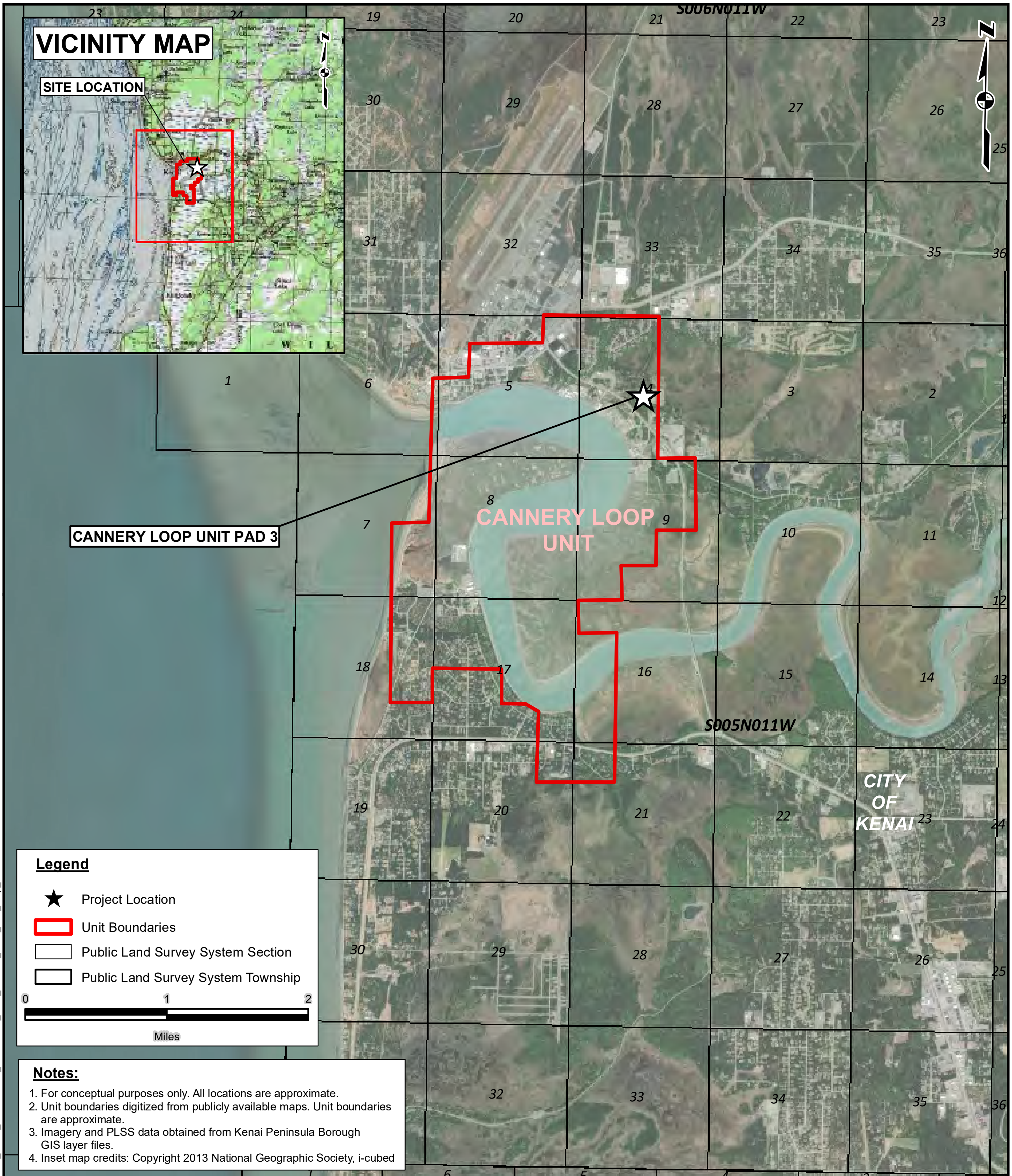

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Anchorage, AK 99503

2021 GROUNDWATER MONITORING PROGRAM WORK PLAN
BEAVER CREEK UNIT PAD 4, CANNERY LOOP UNIT PAD 3,
KENAI GAS FIELD
KENAI PENINSULA, ALASKA

CANNERY LOOP UNIT SITE MAP

DATE: 5/25/2021
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FIGURE: 3

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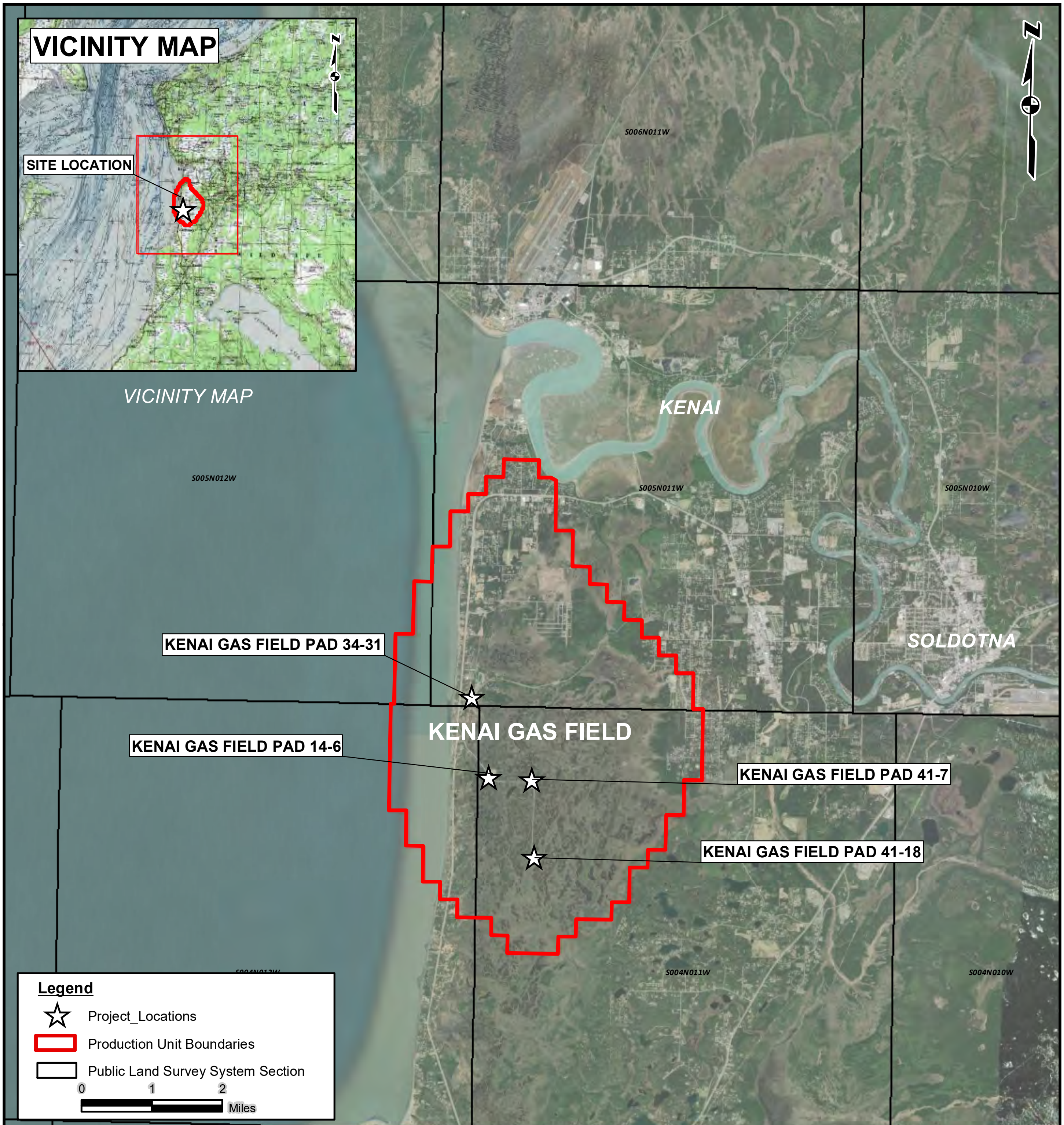

Notes:

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.

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2021 GROUNDWATER MONITORING PROGRAM REPORT - BEAVER CREEK UNIT PAD 4

KENAI PENINSULA, ALASKA

BEAVER CREEK UNIT PAD 4 MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

- 132 — Groundwater Contour with Elevation (feet)
- XX.XX — Groundwater Elevation (feet)
- Approximate Groundwater Flow Direction

Monitoring Well Location

- Gauge - LNAPL Previously Present; Sample if no LNAPL Detected
- Gauge Only
- Gauge and Sample
- Gauge and Sample; Previous Exceedance
- To be Decommissioned

Notes

1. For conceptual purposes only. Site feature locations are approximate.
2. Imagery acquired from Quantum Spatial Inc. Imagery was taken on 31 May 2017.
3. All presented groundwater results are based on findings from 2019 activities.
4. Groundwater elevations provided in NAVD88 datum.
5. Groundwater contours were generated with Surfer 16 software using kriging and groundwater gauging data collected from each well within two hours. WellsAP-15, AP-25, AP-27, and AP-29 were excluded.
6. Well AP-25 was excluded from water table modeling because it was not accessible at the time of gauging,
7. Wells AP-15 and AP-29 were excluded from water table modeling because water levels were not measured at the time of gauging due to the wells containing LNAPL (NM = not measured).
8. PVC riser (casing) on AP-27 was found to be sheared off near ground level. Groundwater elevation could not be calculated for this well and excluded from water table modeling.

80 40 0 80 FEET

ALASKA STATE PLANE ZONE 4, US SURVEY FEET

HORIZONAL DATUM: NAD83 (2011) | VERTICAL DATUM: NAVD88

Brice ENGINEERING

Fairbanks Office
301 Cushman Street, Suie 100
Fairbanks, AK 99701
907.456.1955 (office)
907.452.5018 (fax)

Anchorage Office
3700 Centerpoint Drive, Suite 8223
Anchorage, AK 99503
907.275.2896 (office and fax)

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2021 GROUNDWATER MONITORING PROGRAM REPORT - CANNERY LOOP UNIT PAD 3

KENAI PENINSULA, ALASKA

MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

- 31.0 — Groundwater Contour with Elevation (feet)
- XX.XX — Groundwater Elevation (feet)
- Approximate Groundwater Flow Direction

Monitoring Well Location

- Gauge Only
- Gauge and Sample
- Gauge and Sample; Previous Exceedance
- Existing Structure
- Former Reserve Pit Outline (approximate)

Notes

1. For conceptual purposes only. Site feature locations are approximate.
2. Imagery acquired from Quantum Spatial Inc. Imagery was taken on 31 May 2017.
3. All presented groundwater results are based on findings from 2019 activities.
4. Groundwater elevations presented in feet (NAVD88).
5. Groundwater contours were generated in Surfer 16 using kriging and designated water table modeling wells MW-5, MW-7, MW-9, MW-10, MW-11, and MW-12.
6. All viable wells were last surveyed on 17 October 2017.

50 25 0 50 FEET

ALASKA STATE PLANE ZONE 4, US SURVEY FEET
HORIZONAL DATUM: NAD83 (2011) | VERTICAL DATUM: NAVD88

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Fairbanks Office
301 Cushman Street, Suie 100
Fairbanks, AK 99701
907.456.1955 (office)
907.452.5018 (fax)

Anchorage Office
3700 Centerpoint Drive, Suite 8223
Anchorage, AK 99503
907.275.2896 (office and fax)

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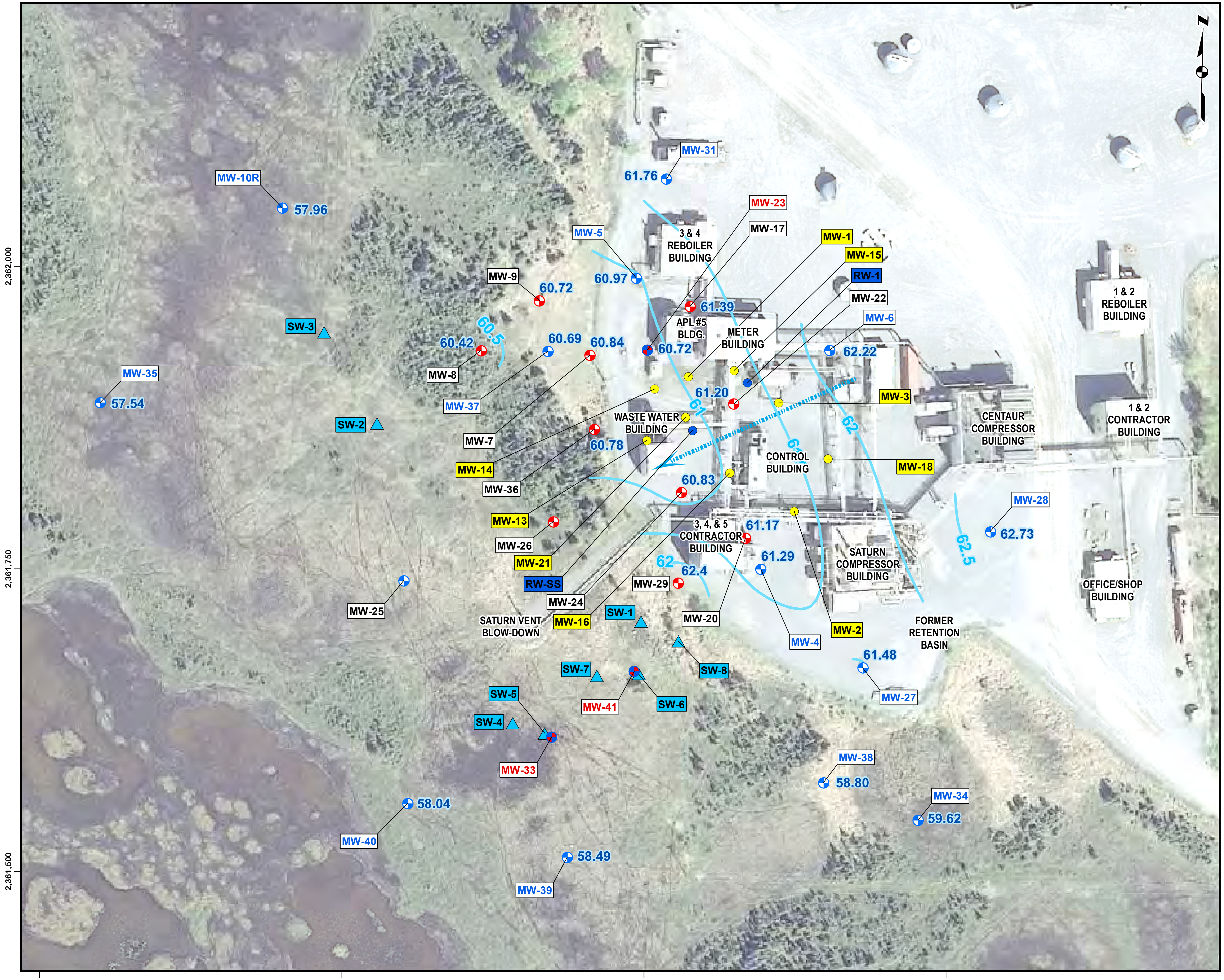

2021 GROUNDWATER MONITORING PROGRAM REPORT - KENAI GAS FIELD

KENAI PENINSULA, ALASKA

KENAI GAS FIELD PAD 14-6
MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

- 64.5 — Groundwater Contour with Elevation (feet)
- XX.XX — Groundwater Elevation (feet)
- Approximate Groundwater Flow Direction

Monitoring Well Location

- High Vacuum Extraction (Inaccessible)
- Deep Aquifer Well (not in Contaminated Sites Program)
- Gauge - LNAPL Previously Present; Sample if no LNAPL Detected
- Gauge Only
- Gauge and Sample; Previous Exceedance
- Surface Water Sample Location

Notes

1. For conceptual purposes only. All locations are approximate.
2. Imagery acquired from Quantum Spatial Inc. Imagery was taken on 31 May 2017.
3. All presented groundwater results are based on findings from 2019 activities.
4. Groundwater elevations presented in NAVD88 datum.
5. Groundwater contours were generated with Surfer 16 software using kriging and designated water table modeling wells MW-5, MW-6, MW-8, MW-20, MW-22, MW-27, MW-28, MW-29, MW-31, MW-36.
6. Monitoring wells MW-10R, MW-25, MW-34, MW-35, and MW-39 were proposed as water table modeling wells, but could not be used in 2019 due to lack of surveyed casing elevations in the NAVD88 datum.

80 40 0 80 FEET

ALASKA STATE PLANE ZONE 4, US SURVEY FEET
HORIZONAL DATUM: NAD83 (2011) | VERTICAL DATUM: NAVD88

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Fairbanks Office
301 Cushman Street, Suie 100
Fairbanks, AK 99701
907.456.1955 (office)
907.452.5018 (fax)

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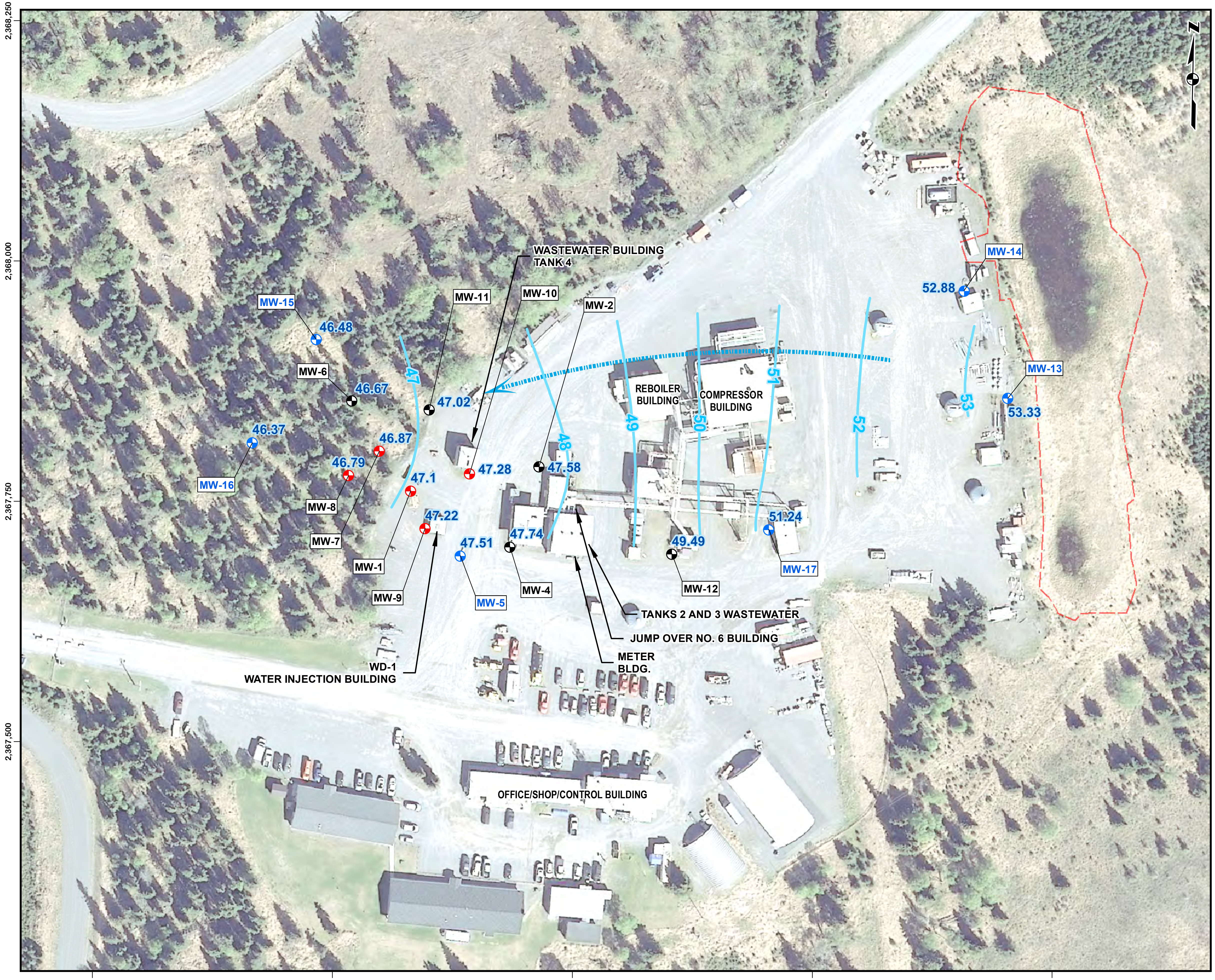
2021 GROUNDWATER MONITORING PROGRAM REPORT - KENAI GAS FIELD

KENAI PENINSULA, ALASKA

KENAI GAS FIELD PAD 34-31 MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION



Legend

47	Groundwater Contour with Elevation (feet)
XX.XX	Groundwater Elevation (feet)
	Approximate Groundwater Flow Direction
	Approximate Extent of Excavation to Remove Eastern Reserve Pit (1996)

Monitoring Well Location

- Gauge Only
- Gauge and Sample
- Gauge and Sample; Previous Exceedance

Notes

1. For conceptual purposes only. All locations are approximate.
2. Imagery acquired from Quantum Spatial Inc. Imagery was taken on 31 May 2017.
3. All presented groundwater results are based on findings from 2019 activities.
4. Groundwater elevations provided in NAVD88 datum.
5. Groundwater contours were generated with Surfer 16 software using kriging and designated water table modeling wells MW-2, MW-9, MW-12, MW-13, MW-14, MW-15, MW-16, and MW-17.
6. Approximate former reserve pit excavation boundary is digitized from the 2012 Groundwater Monitoring Report (Weston).

100 50 0 100 FEET

ALASKA STATE PLANE ZONE 4, US SURVEY FEET
HORIZONAL DATUM: NAD83 (2011) | VERTICAL DATUM: NAVD88

Fairbanks Office
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Fairbanks, AK 99701
907.456.1955 (office)
907.452.5018 (fax)

Anchorage Office
3700 Centerpoint Drive, Suite 8223
Anchorage, AK 99503
907.275.2896 (office and fax)

PROJECT No.: 760101	DATE: 5/25/2021	FIGURE: 8
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2021 GROUNDWATER MONITORING PROGRAM REPORT - KENAI GAS FIELD

KENAI PENINSULA, ALASKA

KENAI GAS FIELD PAD 41-7 MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

- 66.4 — Groundwater Contour with Elevation (feet)
- XX.XX — Groundwater Elevation (feet)
- Approximate Groundwater Flow Direction

Monitoring Well Location

- Gauge Only
- Gauge and Sample
- Gauge and Sample; Previous Exceedance
- Surface Water Sample Location

Notes

1. For conceptual purposes only. All locations are approximate.
2. Imagery acquired from Quantum Spatial Inc. Imagery was taken on 31 May 2017.
3. All presented groundwater results are based on findings from 2019 activities.
4. Groundwater elevations provided in NAVD88 datum.
5. Groundwater contours were generated with Surfer 16 software using kriging and designated water table modeling wells MW-16R, MW-17, MW-19, MW-21R, MW-25, MW-27, MW-29, MW-33, and MW-37.

100 50 0 100 FEET

ALASKA STATE PLANE ZONE 4, US SURVEY FEET

HORIZONAL DATUM: NAD83 (2011) | VERTICAL DATUM: NAVD88

BRICE ENGINEERING

Fairbanks Office
301 Cushman Street, Suie 100
Fairbanks, AK 99701
907.456.1955 (office)
907.452.5018 (fax)

Anchorage Office
3700 Centerpoint Drive, Suite 8223
Anchorage, AK 99503
907.275.2896 (office and fax)

PROJECT No.:	DATE:	FIGURE:
760101	5/25/2021	9
P.M.: KL	DRAWN: JC	

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1 INCH

2021 GROUNDWATER MONITORING PROGRAM REPORT - KENAI GAS FIELD

KENAI PENINSULA, ALASKA

KENAI GAS FIELD PAD 41-18
MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

- 68.5 — Groundwater Contour with Elevation (feet)
- XX.XX — Groundwater Elevation (feet)
- Approximate Groundwater Flow Direction

Monitoring Well Location

- Gauge Only
- Gauge and Sample
- Gauge and Sample; Previous Exceedance
- Surface Water Sample Location

Notes

1. For conceptual purposes only. All locations are approximate.
2. Imagery acquired from Quantum Spatial Inc. Imagery was taken on 31 May 2017.
3. All presented groundwater results are based on findings from 2019 activities.
4. Groundwater elevations provided in NAVD88 datum.
5. Groundwater contours were generated with Surfer 16 software using kriging and designated water table modeling wells MW-3R, MW-8R, MW-12, MW-15, MW-16, and MW-19.

80 40 0 80 FEET

ALASKA STATE PLANE ZONE 4, US SURVEY FEET
HORIZONAL DATUM: NAD83 (2011) | VERTICAL DATUM: NAVD88

Brice ENGINEERING

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Anchorage Office
3700 Centerpoint Drive, Suite 8223
Anchorage, AK 99503
907.275.2896 (office and fax)

PROJECT No.: 760101	DATE: 5/25/2021	FIGURE: 10
P.M.: KL	DRAWN: JC	

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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 content and format of field logbooks. It was generated in accordance with the Alaska Department of Environmental Conservation (ADEC) *Field Sampling Guidance* (ADEC 2019) and United States Army Corps of Engineers, Alaska District requirements. This SOP will be used to direct personnel in field documentation and record keeping requirements 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 used 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 Lead designates 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 must be entered in permanent ink.

3.1 FRONT COVER

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

- Owner of the book (Example: Brice Engineering, LLC)
- Book number
- Job name and Contract number
- Start date
- End date

3.2 PROJECT CONTACT INFORMATION

Include project contact information on the inside front cover or first page of the logbook. Contact information may include 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 must abide by the following guidelines:

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

The minimum daily standard logbook entries include the following:

- Date and time
- Work start and stop times
- Full names, titles and roles of personnel on site, including visitors
- Safety meetings/tailgates
- Level of PPE
- Name(s) of person(s) collecting samples or performing work
- Location of work areas (excavations and landfill areas) and sampling points (sketches with north arrows when appropriate)
- Sample identification numbers and descriptions
- Sample shipping information (date, time, destination, location)
- Type of field instrumentation (model and serial numbers)
- All calibrations performed
- Other work performed
- Any deviations from the work plan

Correct erroneous field record or logbook 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 are maintained as part of the field forms. These entries are recorded in weatherproof ink on weatherproof paper.

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 are downloaded to a designated location. Take care when downloading, storing, and managing data. Naming conventions (according to the project-specific work plan) are used to indicate the project, date, and other relevant information.

3.6 DOCUMENT CONTROL

At the conclusion of a task or project, all field documentation, including logbooks, field forms, photographs, etc., is scanned and placed in a designated location (typically the "Field" folder) and maintained for project use.

4.0 REFERENCES

ADEC. 2019 (October). *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* (October 2019). This SOP will be used to direct field personnel in sample chain-of-custody (COC) management. 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 include the following:

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

3.0 SAMPLE HANDLING PROCEDURE

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

3.1 SAMPLE COC DOCUMENTATION

Sample identification documents are 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.
- In an authorized person's possession and then secured (locked up).
- Kept in a secured area that is restricted to authorized personnel.

3.2 FIELD CUSTODY PROCEDURES

The following procedures are used by field personnel:

- The sample collector is 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 records sample data (time of collection, sample number, analytical requirements, and matrix) in the field logbook and/or on the appropriate field form.
- Sample labels are completed for each sample, using weatherproof ink.

3.3 CHAIN-OF-CUSTODY RECORD

The COC record is fully completed prior to sample shipment. When possible, an electronic COC record should be used. Required information on the COC includes the following:

- Client (contractor name)
- Reporting Information (Chemist name and contact information)
- Project Name
- Invoice information
- PO Number
- COC number
- Cooler ID
- Page number
- NPDL number
- Field Sample ID
- Location ID
- Collection date
- Collection time (in 24-hour format)
- Sampler initials
- Quantity (number of containers)
- Container types (VOA, amber, 40 mL, etc.)
- Container volumes
- Preservative
- Sample matrix (soil, water, other)
- Requested laboratory analysis methods required for each jar
- Quality control (trip blanks and MS/MSD)
- Turn-around-time (TAT)
- Notes
- Special instructions

3.4 SAMPLE PACKAGING

Samples are labeled and packaged according to the *Labeling, Packaging, and Shipping Samples* SOP (BE-SOP-03). The COC record accompanies all sample shipments. Two COC records are prepared for each shipment. One COC record is placed in a re-sealable plastic bag with the bag sealed shut to prevent water intrusion from moisture in the cooler, and the bag is taped inside the cooler lid. The duplicate or electronic copy of the COC record is retained by the sampler and provided to the Project Chemist and other sample coordinators. Airway bills are retained with the COC record and provided to the Project Chemist, so sample pickup can be coordinated with the laboratory. Airway bills must be scanned and placed in a designated location, typically the "Field" folder, and maintained for project use.

3.5 CUSTODY SEALS

Custody seals are preprinted, adhesive-backed seals with security slots designed to break if the seals are disturbed. Seals are signed and dated at the time of use. Sample shipping containers (coolers) are sealed in as many places as necessary to ensure that the container cannot be opened without tearing the custody seals. Typically, one custody seal is placed along the front corner of the cooler, and a second is placed along the opposite back corner of the cooler. Clear tape is 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 sample handler 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 must sign, date, and note the time as "relinquished by" on the COC record. The receiver also signs, dates, and notes 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 does not sign the COC record; rather, the COC record is signed by the sampler as "relinquished by" prior to closing the sample coolers for shipment and relinquishing them to the commercial carrier.

3.7 LABORATORY CUSTODY PROCEDURES

A designated sample custodian accepts custody of the shipped samples and verifies that the sample identification number matches the COC record. The laboratory completes a cooler receipt form when samples are received. The cooler receipt form documents any discrepancies identified between the sample labels and COC, cooler temperature(s), sample preservation, and sample integrity. Cooler receipt information, including a signed COC, custody seals, and a completed cooler receipt form, are provided to the Project Chemist and emailed to receipt.cooler@usace.army.mil within 24 hours of cooler receipt.

4.0 REFERENCES

ADEC. 2019 (October). *Field Sampling Guidance*.

ATTACHMENTS

Attachment A Chain-of-Custody Form

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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:

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

Received By: Received By:

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 for labeling, packaging, and shipping samples from the field to the laboratory for analysis.

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 includes:

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

3.0 PROCEDURES

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

3.1 LABELING

Samples must be labeled using nomenclature defined in the project-specific work plan. All sample labels must be weatherproof and contain the following information:

- Project or project number
- Sampler name or initials
- Sample identification
- Sample date and time (in 24-hour format)
- Laboratory analysis methods required for sample jar
- Preservatives added to sample jar

Adhesive sample labels are 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 or tape 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 to withstand shipment. Secure and tape the drain plug with duct tape.
2. Be sure that container lids 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 the sample identification exactly matches the chain-of-custody record.
4. 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. Wrap and package containers sufficiently to prevent cross contamination and ensure that containers remain intact during shipment (bubble wrap and plastic zip-top bags).
5. 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.
6. Line the cooler with a contractor-grade plastic bag.
7. Place the containers inside the contractor-grade plastic bag with caps up.
8. 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.
9. If the cooler contains volatile samples, ensure that a trip blank is included.
10. Fill excess space between sample containers with additional bubble wrap or gel ice.
11. Tape the top of the contractor-grade plastic bag shut once all sample containers, trip blanks, and the temp blank are inside.
12. 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. **Use sufficient ice in packaging to ensure that samples are received by the laboratory at the proper temperature of 0 to 6°C. 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.**
13. Fill remaining headspace with additional packing material.
14. 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.
15. 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.
16. 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.

17. 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, a dangerous goods "candy-striped" form and Notification to Caption (NOTOC) are not required (IATA 2020).

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 once filled; 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. (2020). *Dangerous Goods Regulations (DGR) Limited/Excepted Quantities Labels.*

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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 SAMPLING PROCEDURE

The following sections describe different QC sample types that may be required in project-specific work plans.

2.1 FIELD DUPLICATE

A field duplicate is collected to evaluate whether sample matrix heterogeneity, contaminant distribution, or sample collection methods affect analytical precision. The field sampler ensures that primary and duplicate samples are effectively identical by collecting the samples from the same location, at the same time, with the same techniques, and from the same matrix. Non-volatile samples should be homogenized in a metal bowl or sealable zip-top bag prior to sample collection. Volatile samples should not be homogenized to minimize loss of volatile constituents; however, an effort should be made to collect samples from the same matrix and part of the sample interval.

At a minimum, one blind field duplicate should be collected per day and per 10 samples for each analytical method and matrix for offsite laboratory analysis. In some cases, such as when only one monitoring well per day can be sampled because of low yielding groundwater, it is not feasible to achieve the one field duplicate per day requirement. If anticipated prior to conducting project work, these site-specific deviations should be included in the site-specific work plan. If multiple sample coolers are shipped together, an effort should be made during sample packaging to include a duplicate in each cooler.

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] 2019). A duplicate sample collection time of one hour before the primary sample time is recommended to ensure there are no holding time issues.

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

MS/MSD samples are collected to evaluate the precision and accuracy of laboratory procedures in the project sample matrix. The MS/MSD compound is 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 a matching sample identification and time denoted on the chain-of-custody (CoC) form to ensure that the project MS/MSD pair is used in the laboratory report. The MS/MSD should be noted in the QC column of the CoC. At a minimum, the frequency of MS/MSD samples collected is one for each analytical batch. Note that the analytical laboratory often batches samples in the same cooler together for shipments containing multiple coolers, so an effort should be made during sample packaging to include an MS/MSD in each cooler. The MS/MSD evaluation process is specified in the QAPP.

2.3 TEMPERATURE BLANK

A temperature blank must 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 and 6 degrees Celsius (°C). Temperature blanks consist of plastic bottles filled with water, typically prepared by the laboratory. Once shipments are received by the laboratory, the temperature is recorded on the CoC to document that preservation requirements were met.

2.4 TRIP BLANKS

Trip blanks must accompany volatile samples, 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 sample bottle transport to and from the field. Trip blanks are samples of reagent-grade water, properly preserved in a controlled environment by the laboratory prior to field mobilization. Trip blanks are kept with the sample containers throughout the sampling process and returned to the laboratory with the analytical samples. One trip blank must accompany each cooler containing volatile samples. All trip blanks must be labeled and included on the CoC. Trip blank sample times will be recorded as 0800 on the CoC. The trip blank evaluation process is specified in the QAPP.

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 or pumping 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 equipment rinsate blank collection frequency and evaluation process are specified in the QAPP. Decontamination procedures must be performed according to the *Equipment Decontamination* SOP (BE-SOP-14).

3.0 REFERENCES

ADEC. 2019 (October). *Field Sampling Guidance*.

STANDARD OPERATING PROCEDURE

BE-SOP-09

Groundwater Sample Collection

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) provides methodology for planning groundwater sampling events and collection of groundwater samples.

This SOP was developed in accordance with the following guidance documents:

- *Field Sampling Guidance* (Alaska Department of Environmental Conservation [ADEC], 2019)
- *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers* (U.S. Environmental Protection Agency [EPA] 2002)
- *Low Stress (Low Flow)-Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells* (EPA 2017).
- *Standard Practice for Low-Flow-Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations* (American Society for Testing and Materials [ASTM] 2018)
- *Underground Storage Tanks Procedures Manual: Guidance for Treatment of Petroleum-Contaminated Soil and Groundwater and Standard Sampling Procedure* (ADEC 2017)

This SOP focuses on the most commonly used monitoring well sampling tasks and should be used in conjunction with other applicable SOPs, including the following:

- BE-SOP-01: *Logbook Documentation and Field Notes*
- BE-SOP-02: *Sample Chain of Custody*
- BE-SOP-03: *Labeling, Packaging, and Shipping Samples*
- BE-SOP-04: *Quality Control Samples*
- BE-SOP-05: *Drilling and Core Logging*
- BE-SOP-14: *Equipment Decontamination*
- BE-SOP-20: *Water Quality Measurements*
- BE-SOP-22: *Monitoring Well Installation, Development, and Decommissioning*
- BE-SOP-66: *Breathing Zone Air Monitoring*

Groundwater sampling consists of collecting a water sample that is representative of the aquifer. Representative samples can be analyzed for groundwater contamination and/or naturally occurring analytes. Three common methods for well sampling include:

1. Low-Flow Method
2. Well-Volume Method
3. Low-Permeability Formation Method

Monitoring well sampling can be initiated as soon as the groundwater has re-equilibrated, is free of visible sediment, water quality parameters have stabilized, or 24 hours have passed following development (ADEC 2019).

Disturbance of the well, water column, and samples must be minimized, and only discrete grab samples may be collected. If multiple wells are to be sampled, the wells should be sampled from the least contaminated well progressing to higher levels of contamination. Groundwater samples need to be collected and analyzed for all appropriate contaminants of concern based on Appendix E of the *Field Sampling Guidance* and the project-specific work plan. Samples must be collected in the order of volatility (ADEC, 2019):

1. Volatile organic compounds (VOCs) and gasoline range organics (GRO)
2. Semi-volatile organic compounds (SVOCs); including diesel range organics/residual range organics (DRO/RRO), polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, and herbicides
3. Total organic carbon (TOC), and
4. Inorganic compounds (total metals, dissolved metals, nitrate/nitrite, and sulfide)

2.0 EQUIPMENT AND SUPPLIES

Groundwater sampling can be performed using several devices including submersible pumps, bladder pumps, peristaltic pumps, and bailers. Groundwater sampling devices must support the intended data use and site decisions, and selected groundwater purging and sampling equipment must minimize increases in sample temperature, water column agitation, and sample agitation (ADEC, 2019).

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

- Appropriate level of personal protective equipment
- Well keys
- Camera
- Logbook, weatherproof pen, sharpie, etc.
- *Groundwater Sampling Form* (Attachment 1)
- Sample labels
- Sampling containers and packing materials
- Oil/water interface probe or water level indicator
- Submersible (e.g., Proactive Monsoon pump with low-flow controller, or equivalent), bladder (e.g., QED Sample Pro), or peristaltic pump (e.g., MasterFlex Easy-Flow)
- Disposable Teflon bailers and twine
- Graduated cylinder or beaker
- YSI water-quality meter or similar multimeter
- Hach turbidimeter
- Potable water and/or deionized water
- Tubing (Teflon, high-density polyethylene [HDPE] and/or silicone)
- Liquinox, Alconox, or equivalent
- RAE Systems MiniRAE photoionization detector (PID) (or similar), if necessary
- Colorimetric gas detector tubes, if necessary

3.0 PROCEDURES

3.1 RECORDING FIELD OBSERVATIONS

The *Groundwater Sampling Form* (Attachment 1) is intended to capture all of 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 Form*.

3.2 FIELD EQUIPMENT DECONTAMINATION

Clean and/or decontaminate all equipment and materials used during groundwater sampling before use, as discussed in *Equipment Decontamination* (BE-SOP-14). Groundwater sampling equipment that typically requires decontamination includes all measurement devices before and between measurements at each well, groundwater sampling pumps between sampling at each well, water quality meters and probes and the inside of flow-through cells (ADEC, 2019). Used decontamination solution will be managed as investigation-derived waste, according to the project-specific work plan.

3.3 FIELD INSTRUMENT CALIBRATION

Field instruments will be calibrated in accordance with the manufacturer's recommended procedures and frequency for each instrument. Refer to *Water Quality Measurements* SOP (BE-SOP-20) and *Field Screening with PID* SOP (BE-SOP-15) for related procedures.

3.4 AIR MONITORING

Air monitoring will be conducted to screen for the presence of VOCs using a PID, or colorimetric gas detector tubes, if necessary. PID readings will be monitored until stable and then recorded in the field logbook. Procedures in the project-specific Site Safety and Health Plan (SSHP) and *Breathing Zone Air Monitoring* SOP (BE-SOP-66) will be followed if organic vapors are detected above concentrations listed in the air monitoring section of the SSHP.

Prior to removing the well plug, remove any standing water in the well annulus. Collect PID readings in situations as follows:

- 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.

3.5 FREE PRODUCT AND WATER LEVEL MEASUREMENT

Measure the depth to groundwater (DTW), depth to product (DTP) if present, and total depth (TD) with an oil/water interface probe (or water level meter if no product) to the nearest 0.01-foot. Interface probes provide distinct responses when immersed in nonconductive product or conductive water. If non-aqueous phase liquid (NAPL) is encountered in a well, unless otherwise specified in the project-specific work plan, do not collect laboratory samples (ADEC 2019). If samples are to be collected, remove the product with a bailer and make a note on the chain of custody that free product is present.

DTW, DTP, and TD are measured relative to an established reference mark from the top of the casing (TOC). The reference mark should be permanent, such as a small notch cut into the TOC or a permanent ink mark at the TOC. If a reference mark is not present, place a mark on the outside of the top north side of the well casing with indelible ink.

TD of a monitoring well should be compared to the well construction log to determine the thickness of silt present on the bottom, if present.

3.6 PURGING

Purging is the process by which stagnant water is removed from the well casing 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 2019). Monitoring wells will be purged, at a minimum, the equivalent of three times the well volume, or until a minimum of three (four, if using temperature) water quality parameters stabilize, or for low yield wells, the entire well casing is evacuated.

The formula to calculate one well casing volume is as follows:

*(TD of Casing – DTW) * Gallons per Foot of Casing*

Refer to Attachment 1 for the various gallons per foot of casing based on the diameter of the well.

All measurements, except turbidity, must be obtained using a flow-through cell. Water quality parameter stabilization is reached when three consecutive changes between successive readings at approximately 3 – 5 minute intervals are within:

- ± 3% for temperature,
- ± 0.1 for pH,
- ± 3% for conductivity,
- ± 10 millivolts for oxidation reduction potential,
- ± 10% for dissolved oxygen,
- ± 10% or ≤ 10 NTU for turbidity.

3.7 GROUNDWATER SAMPLING

3.7.1 Low-Flow Method

The low-flow sampling method uses groundwater quality parameters as indicators to determine when formation water is being discharged. Sampling at low-flow rates provides more accurate and reproducible samples of the formation water by minimizing hydraulic stress compared to high flow/high volume purging, while also reducing purge water volume. Low-flow sampling is not suitable for very low-yield wells, sampling in wells known to contain NAPL, and may require longer purge times (ASTM 2018).

Low-flow sampling is typically conducted using bladder pumps (positive displacement pumps), submersible pumps or peristaltic pumps. The use of Teflon-lined polyethylene tubing is preferred for the sample collection of organic compounds. For the analysis of per- or polyfluorinated alkyl substances hydrocarbons (PFAS) HDPE tubing is to be used; however, the use of HDPE equipment should be minimized to the extent practical (ADEC 2019).

Sampling of wells in order of increasing chemical concentrations (known or anticipated) is preferred. If wells contain free product, alternate wells that are representative of the affected groundwater should be sampled instead. Samples will be collected using the following steps:

- Measure and record the initial water level before installing the pump.
- Lower the pump or peristaltic pump tubing to the target depth below the static water level.
    - Record the depth of the pump on the Groundwater Field Data Form.
    - Consult the project-specific work plan for pump placement. Typically:
        - 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 (ADEC, 2017).
        - For wells with submerged screens, set the pump intake at the middle of the screened interval (ASTM 2018).
- Begin purging water into a graduated bucket. Adjust the flow rate, as needed, so that drawdown does not exceed 0.33 feet (EPA 2002, ADEC 2019).
    - Flow rates typically range from 50 to 500 milliliters per minute (mL/min) (0.01 to 0.13 gallons per minute[gal/min]), but higher rates are consistent with low-flow guidelines as long as the drawdown requirement is met (ADEC 2019).
    - Flow adjustments are best made in the first 15 minutes of pumping in order to minimize purging time.
- After observable turbidity decreases, connect the flow-through cell to begin measuring and recording stabilization parameters and DTW on Attachment 1.
- Continue to purge and record measurements until stabilization criteria are met (Section 3.6) or a minimum of three or maximum of six well casing volumes are removed (EPA 2002).
- When collecting samples, disconnect the tubing from the flow-through cell and collect samples directly from the pump's tubing.
- Begin filling laboratory-supplied analytical sample containers in order of volatility as described in Section 1.0.
- Record sample information on the sample bottle labels and Attachment 1.

3.7.2 Well-Volume Method

This method is the default method used during low-flow sampling if groundwater stabilization parameters cannot be achieved. The well-volume method is based on purging three to six well volumes before sampling (EPA, 2002). One well casing volume of water may be calculated using the formula in Section 3.6.

Well-volume method sampling should be conducted as above in the Low-Flow Method, but:

- The purge rate should not be great enough to produce excessive turbulence in the well.

  - Flow rates typically range from 500 mL/min to 3.8 L/min (0.13 to 1 gal/min) in a 2-inch well (EPA 2002).
- Routinely measure and record groundwater parameters and DTW at approximately every 0.5 – 1 well volume interval on Attachment 1 (EPA 2002).
- Once groundwater parameters have stabilized and a minimum of three well casing volumes have been removed, record the final measurements.
- If parameters have not stabilized within six well volumes, stop purging and record the final measurements.
- Reduce the flow rate of the pump to about 0.13 gal/min and collect samples as above (EPA 2002).

3.7.3 Low-Permeability Formation Method

If a well is screened in low hydraulic conductivity aquifers (silt and clay) there may be no way to avoid pumping or bailing a well dry. Low-flow purging and sampling are useful for wells that purge dry or take one hour or longer to recover (ADEC 2019).

If a low yield well is purged dry, and it is not possible to obtain groundwater stability parameters:

- Purge the well dry and allow the well to recover until at least one of the following is met:
  - If full recovery exceeds one hour, collect samples as soon as the well has recharged to 80 percent of the DTW (ADEC 2019).
  - A minimum of 2 hours has passed since purging (EPA 2002).
  - There is sufficient water volume present to obtain a sample.
- Collect samples in order of volatility, as described in Section 1.0.
  - Bailers or a peristaltic pump may be used; however, analytical results may be biased low for VOCs if using a peristaltic pump or biased high for metals if using a bailer due to increased turbidity (EPA 2002).

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. Cross-contamination can be a significant problem when attempting to characterize low concentrations of organic compounds or when soils are highly contaminated (ADEC 2017). To prevent cross-contamination between wells, dedicated tubing can 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, the purge rate will be maintained at a rate that produces minimal drawdown until three well casings have been removed or until water quality parameters have stabilized, as described in Section 3.6.

5.0 SAMPLE HANDLING, PRESERVATION, AND STORAGE

The following procedure will be followed for sampling 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 involve 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 REFERENCES

ADEC. 2017 (March). *Underground Storage Tanks Procedures Manual: Guidance for Treatment of Petroleum-Contaminated Soil and Groundwater and Standard Sampling Procedure.*

ADEC. 2019 (October). *Field Sampling Guidance*.

ASTM. 2018 (September). D6671 - *Standard Practice for Low-Flow-Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations*

U.S. EPA. 2002 (May). *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*. Office of Solid Waste and Emergency Response. EPA 542-S-02-001.

U.S. EPA. 2017 (September). *Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells*. EPA 540-S-95-504.

ATTACHMENTS

Attachment 1   Groundwater Sampling Data Form

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GROUNDWATER SAMPLING DATA FORM

Well ID:______________________

Project Name: ______________________ Date: ______________________

Project Number: ______________________ Start Time: ______________________

Sampling Team: ______________________ End Time: ______________________

Sample ID: ______________________ Time: __________ primary dup other: __________

Sample ID: ______________________ Time: __________ primary dup other: __________

Sample ID: ______________________ Time: __________ primary dup other: __________

Depth to Top of Product (BTOC): __________ Total Depth (BTOC): __________

Depth to Oil/Water Interface (BTOC): __________ Depth to Water (BTOC) __________

Casing Diameter:	*1 in.*	*2 in.*	*4 in.*
gal/ft of casing:	*0.041*	*0.163*	*0.653*

Water Column (ft) __________

Casing Volume (gal) __________

Pump Intake Depth: __________ Screen Interval __________

Stable DTW (BTOC): __________ Measured Stick-up __________

Method of Purging (circle one):

Pump: SUB BLDR PERIST OTHER: Bailer: TEFLON SS OTHER:

Pump Type: Flow Rate (gpm): Required Pulls: Bailer Vol. (gal): 0.25 / 0.33

Pump Time: Vol. Purged (gal):

WELL STABILIZATION DATA

Time	Total Volume Purged (gallons)	Water Level (ft BTOC)	Draw Down	Temp. (°F or °C)	pH	Conductivity (µS/cm)	ORP (mV)	D.O. (mg/L)	Turbidity (NTU)
				± 3%	± 0.1	± 3%	± 10mV	± 10%	± 10% or <10 NTU

Notes: Drawdown should be less than 0.3 feet from the original DTW. Minimal drawdown achieved and measured by: 1) pumping at a low rate (approx. 1 liter/3 minutes or 0.26 gallons/3 minutes or 50-500 mL/min) **and** 2) continually measuring water levels in the well.
Sample after 1) removing min. of 3 casing volumes **or** 2) min. of 3 parameters stabilize (4, if using temp.), **or** 3) for low yield wells, entire well casing is evacuated (ADEC, 2013).

Sensory Observations

Color: Clear, Amber, Tan, Brown, Gray, Milky White, Other

Odor: None, Low, Medium, High, Very Strong, H2S, Fuel-Like, Chemical ?, Unknown

Turbidity: None, Low, Medium, High, Very Turbid, Heavy Silts

Comments:

WELL STABILIZATION DATA

Time	Total Volume Purged (gallons)	Water Level (ft BTOC)	Draw Down	Temp. (°F or °C)	pH	Conductivity (µS/cm)	ORP (mV)	D.O. (mg/L)	Turbidity (NTU)
				± 3%	± 0.1	± 3%	± 10mV	± 10%	± 10% or <10 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 procedure 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.

4.0 REFERENCES

ADEC (Alaska Department of Environmental Conservation). 2019 (October). Field Sampling Guidance. Alaska.

ATTACHMENTS

Attachment A 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 may include:

- Level D Personal Protective Equipment (PPE) – nitrile or rubber gloves, safety glasses, safety toed boots, hard hat and safety vest (if decontaminating drilling or heavy equipment)
- Hand tools for bulk contamination removal (shovels, brooms, etc.)
- Liquinox or Alconox
- Spray or rinse bottles, or pump sprayer
- Pressure washer/steam cleaner
- Potable water
- Distilled or deionized water
- Bristle brushes
- Plastic tubs
- Plastic sheeting
- Department of Transportation (DOT)-approved, 5-gallon buckets with screw top lids
- DOT-approved, 55-gallon open-top drums
- Contractor-grade plastic bags
- Paper towels

3.0 PROCEDURE

Reusable sampling equipment must be decontaminated between samples and at the end of each workday. Drilling and excavation equipment should be decontaminated prior to beginning site activities, before collecting each sample when non-dedicated sampling equipment is used, and after completing site activities. Decontamination procedures are detailed in the following subsections.

3.1 DECONTAMINATION AREA

Identify a localized decontamination area for larger drilling and excavation equipment. Select an area with easy access and level ground to minimize slip, trip, and fall hazards. The decontamination area should be large enough to temporarily store clean equipment and materials and stage drums of investigation-derived waste (IDW). When decontaminating larger drilling tooling, such as hollow-stem augers, line each area with a heavy-gauge plastic sheeting and include a collection system designed to capture potential decontamination wastes (water and residual soil). Containerize decontamination water and residual soil in approved containers, such as DOT-approved 55-gallon drums. Decontamination areas should be set up to minimize overspray and risk to the surrounding environment.

Smaller equipment (spoons, trowels, groundwater sampling pumps, etc.) may be decontaminated near the sampling locations. In this case, all required decontamination supplies must be mobilized to the sampling location. A 5-gallon bucket with a screw top lid or a plastic tub should be used to capture decontamination water, which should be transferred to larger containers, as necessary.

3.2 SAMPLING EQUIPMENT DECONTAMINATION

Improper decontamination can cause cross-contamination. To prevent cross-contamination, sampling equipment must be either disposed of after one use or decontaminated after each use. Disposable or dedicated sampling equipment should be used whenever possible. When non-dedicated, reusable equipment is used, it should be decontaminated in stages in a way that minimizes contaminant discharge to the environment. The following procedures should be used:

1) Remove as much bulk contamination as possible from equipment at the point of origin.
2) Wash equipment thoroughly with potable water containing a laboratory-grade detergent, such as Liquinox or Alconox. Use a bristle brush to remove any remaining residual contamination.
3) Rinse equipment thoroughly with potable water.
4) Rinse equipment thoroughly with distilled or deionized water. Note that some instruments can be damaged by deionized water, such as YSI 556 probes.
5) Air dry equipment in clean area free of dust or other fugitive contaminants. Alternatively, wet equipment may be dried with a clean, disposable paper towel to assist the drying process. All equipment should be dry before reuse.
6) Store clean and dry sampling equipment within a protective medium (plastic bag, carrying case, etc.).

3.3 HEAVY EQUIPMENT DECONTAMINATION

Equipment decontamination must be performed prior to transporting or walking equipment between contaminated areas. Decontamination will focus on minimizing the spread of contaminated media resulting from equipment movement or transport. This decontamination process will use dry methods (brooms, brushes, shovels, etc.) within the exclusion zone to remove large, easily dislodged deposits of soil and other contaminated media from equipment (tracks, buckets, etc.) prior to exiting the exclusion zone. The Field Lead may alter decontamination procedures based on dry decontamination effectiveness.

Final decontamination should be conducted when equipment is no longer needed onsite. A decontamination area should be established to collect decontamination materials, sludge, and water. Bulk contamination should be removed using shovels and brushes, and the equipment should be further cleaned using a pressure washer with a detergent wash, followed by a potable water rinse, if needed.

3.4 PERSONNEL AND PERSONAL PROTECTIVE EQUIPMENT (PPE) DECONTAMINATION

During environmental investigations and removal actions, boots and gloves are commonly the most contaminated types of PPE. Contaminated solids such as mud should be scraped and wiped from boots. Personnel decontamination involves removal of bulk contamination first. Any remaining contamination should be removed using soapy water and brushes. Once all debris is removed, rinse the boots with clean water. If boots are not laden with solid materials, a brush can 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 replaced. Gloves should be removed rolling the glove off from the top down to avoid contact with contaminated soil.

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.

4.0 INVESTIGATION DERIVED WASTE MANAGEMENT

Typical investigation derived wastes consist of soil cuttings, decontamination water, and solid wastes.

1) Soil cuttings should be containerized in open-top, DOT-approved, 55-gallon drums. Decontamination water should be collected in plastic troughs or tubs, DOT-approved 55-gallon drums, or DOT-approved 5-gallon buckets with screw top lids.
2) Solid wastes generated during decontamination activities should be containerized in contractor grade plastic bags.
3) All wastes must be treated or disposed of in accordance with applicable state and federal regulations, as specified in the Waste Management Plan.
4) Prior to transporting soil cuttings or decontamination water off-site, an ADEC Contaminated Media Transport and Treatment or Disposal Approval Form must be submitted to the ADEC Project Manager for approval.

5.0 QUALITY CONTROL

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

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STANDARD OPERATING PROCEDURE

BE-SOP-20

Water Quality Measurements

1.0 INTRODUCTION

The purpose of the Standard Operating Procedure (SOP) is to describe the methods of calibrating, maintaining and operating water quality meters and probes used for groundwater sampling. The YSI 556 Multi-Probe System (MPS) and Aqua TROLL 500 are common multimeters used which will simultaneously measure temperature, conductivity, pH, dissolved oxygen (DO), and oxidation reduction potential (ORP). This SOP also describes the guidelines for calibration and operation of the Hach Portable Turbidity Meter. The manufacturer's operator's manual should be referred to for specific calibration, operation procedures and troubleshooting.

This SOP was developed in accordance with the following guidance documents:

- *Field Sampling Guidance* (Alaska Department of Environmental Conservation [ADEC], 2019)
- *Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations* (American Society for Testing and Materials [ASTM], 2018)

This SOP focuses on the mostly commonly used collection methods of field water quality parameters and should be used in conjunction with other applicable SOPs, including the following:

- BE-SOP-01: *Logbook Documentation and Field Notes*
- BE-SOP-09: *Groundwater Sampling*
- BE-SOP-10: *Surface Water Sampling*
- BE-SOP-14: *Equipment Decontamination*
- BE-SOP-21: *Groundwater and LNAPL Measurements*

2.0 EQUIPMENT AND SUPPLIES

Calibration and water quality measurement equipment will include, but is not limited to the following:

- Multimeter, which may include:
    - YSI 556 MPS (or similar)
    - YSI 5563 Probe Module
    - Aqua TROLL 600 Multiparameter Sonde, Wireless TROLL Com communication device, and Aqua TROLL tablet with VuSitu App
- Flow-through cell
- Discharge hoses and fittings to attach sample tubing to the flow-through cell
- Calibration standards (pH 4, 7, and 10, ORP, and conductance)
- Aqua TROLL Quick-Cal Multiple Sensor Solution, if using Aqua TROLL
- Rugged DO (RDO) calibration sponge or 100% saturation bubbler, if using Aqua TROLL

- Deionized water (DI)
- Spray bottle
- Graduated cylinder or beaker, if needed
- 5-gallon buckets
- Portable turbidity meter (e.g., Hach 2100P or Hach 2100Q) and turbidity standards (<0.1, 20, 100, and 800 NTU)
- Appropriate level of personal protective equipment
- Logbook, weatherproof pen, sharpie, etc.
- Multi-parameter and turbidimeter calibration logs (Attachment 1 and 2)

3.0 PROCEDURES

Calibrate or perform a calibration check on equipment daily. Calibration readings should be documented in the field logbook and/or calibration logs (Attachment 1 and 2). 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 Project Manager on whether data collection will continue or if any other corrective actions should be taken. Flag any data recorded from a meter with suspected calibration problems on the field forms. If anomalous field readings are given during sample collection, stop and recalibrate the instrument.

3.1 CALIBRATION OF YSI 556 MPS

The transport/calibration cup that comes with the probe module serves as the calibration chamber and minimizes the volume of calibration reagents required. The key to successful calibration is to ensure that the sensors are completely submersed when calibration values are entered. For maximum accuracy, use a small amount of calibration solution to pre-rinse the probe module (YSI, 2009). Consult the YSI operation's manual for further information (Attachment 3).

3.1.1 pH

Always calibrate pH using the 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. To calibrate pH:

- Select the 3-point option to calibrate the pH sensor using three calibration solutions.
- When calibrating pH, always calibrate with buffer 7 first.
- Place 30 mL of pH buffer into a clean, dry, or pre-rinsed transport/calibration cup, and securely tighten the cup on the threaded end of the probe module.
- Gently rotate and/or move the probe module up and down to remove any bubbles from the conductivity cell.
- Enter the calibration value of the buffer at the current temperature.
- Press **Enter**. The pH Calibration screen is displayed.
- Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

- When the readings show no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to continue.
- After returning to the Calibrate screen, rinse the probe module and sensors with tap or purified water and dry.
- Repeat these steps using a second pH buffer, and then repeat again using a third pH buffer.
- After returning to the Calibrate screen, rinse the probe module and sensors with tap or purified water and dry.

3.1.2 Conductivity

For maximum accuracy, the conductivity standard should be within the same conductivity range as the samples you are preparing to measure.

- For fresh water use a 1 mS/cm conductivity standard.
- For brackish water use a 10 mS/cm conductivity standard.
- For seawater use a 50 mS/cm conductivity standard.

Always calibrate conductivity for specific conductance. Calibrating for specific conductance will automatically calibrate for conductivity and salinity. To calibrate specific conductance:

- Place 55 mL of conductivity standard into a clean, dry, or pre-rinsed transport/calibration cup, and securely tighten the cup on the threaded end of the probe module.
- Gently rotate and/or move the probe module up and down to remove any bubbles from the conductivity cell.
- Enter the calibration value of the standard you are using in mS/cm at 25°C and press **Enter**.
- Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
- When the readings show no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to continue.
- After returning to the Calibrate screen, rinse the probe module and sensors with tap or purified water and dry.

3.1.3 ORP

To calibrate for ORP:

- Place 30 mL of a known ORP solution into a clean, dry, or pre-rinsed transport/calibration cup, and securely tighten the cup on the threaded end of the probe module.
- Gently rotate and/or move the probe module up and down to remove any bubbles from the conductivity cell.
- Enter the correct value of the calibration solution at the current temperature. Refer to the solution values on the calibration standard bottle.
- Press **Enter**. The ORP calibration screen will be displayed.

- Allow at least one minute for temperature equilibration before proceeding. Verify that the temperature reading matches the value you used.
- Observe the reading under ORP. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to continue.
- After returning to the Calibrate screen, rinse the probe module and sensors with tap or purified water and dry.

3.1.4 DO

Always calibrate for % DO. Calibrating for % DO will automatically calibrate for mg/L. The instrument must be on for at least 10 – 15 minutes to polarize the DO sensor before calibrating. To calibrate dissolved oxygen:

- Place 1/8 inch (3 mm) of water in the bottom of the transport/calibration cup.
- Place the probe module into the transport/calibration cup.
    - Make sure the DO and temperature sensors are **not** immersed in the water.
- Engage only 1 or 2 threads of the transport/calibration cup to ensure the DO sensor is vented to the atmosphere.
- Use the keypad to enter the current local barometric pressure in mmHg.
    - If the unit has the optional barometer, no manual entry is required.
- Press **Enter**. The DO % saturation calibration screen will be displayed.
- Allow approximately 10 minutes for the air in the transport/calibration cup to become water saturated and for the temperature to equilibrate before proceeding.
- Observe the reading under DO %. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to continue.
- After returning to the Calibrate screen, rinse the probe module and sensors with tap or purified water and dry.

3.2 AQUA TROLL 500 MULTIPARAMETER SONDE

The restrictor attached in storage/calibration mode serves as the calibration chamber and minimizes the volume of calibration reagents required. For best calibration, it is recommended to rinse twice with the calibration solution to ensure all contaminants have been removed (In Situ, 2019). Aqua TROLL may be calibrated using single sensor calibration standards for pH, conductivity, and ORP. However, the Aqua TROLL sonde may also be calibrated using a multi-sensor calibration standard, Quick-Cal Solution, for these three parameters.

3.2.1 Solution-Based Calibration

Refer to the Aqua TROLL operator's manual if using single sensor calibration standards (Attachment 4). The following procedures will be used for performing a multi-sensor calibration using Quick-Cal Solution:

- Ready the instrument for calibration
    - Remove the rubber bumper and blue top cap from the restrictor.

  - Remove the restrictor and reattach in calibration mode to form the calibration cell.
  - Invert the instrument, so the sensors are facing up.
  - Rinse the sensors with DI or tap water. Ensure the sensor face and inside of calibration cell are clean and free of debris.
- Ready the tablet for calibration
  - From the main menu, select **Connected Instrument.**
  - Select **Calibrations**.
  - Select **Quick-Cal (multi-sensor)**.
    - All available sensors are selected by default. If one or more sensors are not installed properly, an error message will pop up.
  - Select **Next**.
- Solution Rinse Procedure
  - Pour 10 – 20 mL (½-inch above the sensor face) of the calibration standard onto the sensors to perform the first rinse.
  - Ensure the solution comes in contact with the sensors by moving the solution around in the calibration cell. Reinstall the blue top cap and shake gently, if necessary.
  - Discard the calibration standard.
  - Repeat solution rinse procedure. Aqua TROLL recommends two rinses to ensure the best calibration of the instrument.
- Sensor Calibration Procedure
  - Fill the calibration cell with 40 – 50 mL (to the bottom of the threads inside the restrictor) with fresh calibration solution.
    - Check the sensor for bubbles and gently tap to remove any bubbles.
  - Select **Next**.
  - After the calibration is stable, select **Accept**.
  - The calibration values applied to the sensor will appear on-screen. Select **Done** to return to the calibration menu.

3.2.2 DO 100% Saturation Calibration

The RDO sensor is typically calibrated using a 1-point calibration method. The water saturated air method is most commonly used, while the saturation bubbler method requires an additional calibration chamber. Other calibration methods are available in the owner's manual (Attachment 4). The factory calibration of the RDO sensor should produce readings within 3% accuracy (In Situ, 2019). If greater accuracy is required, In-Situ recommends performing a 1-point 100% water-saturated air calibration using the following procedure:

- From the main menu, select **Connected Instrument**.
- Select **Calibrations**.
- Select **RDO Saturation**.
- For a 1-point calibration, select **100% Saturation**.
- Set up the instrument for one of the following methods:

<u>Option 1 – Water Saturated Air</u>

- Remove the restrictor and thoroughly dry the RDO sensing foil and temperature sensor.
- Saturate a small sponge with water (does not need to be dripping).

- Place the sponge in the bottom of the restrictor and attach the end cap, turning one full rotation.
    - Do not fully seal the bottom of the restrictor.
- Wait 5 – 10 minutes for 100% water saturation of the air within the calibration chamber before starting the calibration.
- After the calibration chamber has stabilized, select **Next**.
- After calibration is stable, select **Next**.
- The calibration values will be applied to the sensor and appear on-screen. Select **Done** to return to the Calibration Menu.

<u>Option 2 – Bubbler</u>

- Fill at 100% saturation bubbler half full of tap water.
- Turn on the bubbler.
- Wait 5 – 10 minutes for the bubbler to reach 100% saturation.
- Install the restrictor in deployment mode, remove blue end cap and place the sonde in the bubbler.
- After the calibration chamber or bubbler have stabilized, select **Next**.
- After calibration is stable, select **Next**.
- The calibration values will be applied to the sensor and appear on-screen. Select **Done** to return to the Calibration Menu.

3.3 HACH PORTABLE TURBIDIMETER

The Hach Model 2100P or 2100Q Portable Turbidimeter measures turbidity from 0.01 to 1000 NTU in automatic range mode with automatic decimal point placement. For more information, consult the Hach user manual (Attachment 5). Use the following 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 call compartment so the diamond or orientation mark aligns with the raised orientation mark in from of the cell compartment.
- Press **READ** and the result will show in units of NTU.

3.3.1 Calibration of Hach 2100Q Portable Turbidimeter

For best consistency and accuracy, calibrate using the StablCal Calibration Set and always insert the cell so the orientation mark on the cell is correctly aligned with the mark on the front of the cell compartment (Hach, 2017).

- Push the **Calibration** key to enter the Calibration mode.
    - Gently invert each standard before insertion.
- Insert the 20 NTU StablCal Standard and close the lid.

- Push **Read**. The display shows Stabilizing and then shows the result.
- Repeat with the 100 NTU and 800 NTU StablCal Standard.
- Push **Done** to review the calibration details.
- Push **Store** to save the results.

3.4 COLLECTION OF WATER QUALITY MEASUREMENTS

Water quality parameters (DO, ORP, pH, and conductivity) are chemical properties measured to determine when discharged groundwater is considered representative of the formation water and sampling can begin (ASTM, 2018). Water quality parameters are measured using a multi-parameter instrument coupled with an in-line flow- through cell. The typical volume of the flow-through cell is 500 mL.

3.4.1 Groundwater Parameters

Follow this general procedure for collecting water quality parameters using a flow-through cell:

- Secure the instrument to the flow-through cell. Connect a short discharge tube to the effluent connector at the top of the flow-through cell and run the other end of this discharge tube into a 5-gallon purge water bucket.
- Place the tube from the pump directly into the 5-gallon purge water bucket and purge for approximately half a minute or until the purge water begins to visually clear up. The intent is to limit any initially highly turbid water from accumulating in the flow-through cell.
- Once visually clear, secure the tube from the pump to the influent connector at the bottom of the flow-through cell.
- Continue low flow purging at a flow rate of approximately 1 liter (0.26 gallons) every 3-5 minutes, or 50 – 500 mL/min (ADEC, 2019).
- Routinely measure and record required parameters and the depth to groundwater every 3-5 minutes. A minimum of three recordings will be monitored and recorded.
- Continue to monitor until parameters stabilize or until three well casing volumes have been purged. Use the following stabilization parameters (ADEC, 2019):
  - ± 3% for temperature (minimum of ± 0.2 °C),
  - ± 0.1 for pH,
  - ± 3% for conductivity,
  - ± 10 mv for redox potential,
  - ± 10% for DO, and
  - ± 10% for turbidity.
- When parameters have stabilized, record final measurements, and collect samples per the project-specific work plan.

Note: Low-flow purging and sample collection are particularly useful for wells that purge dry or take one hour or longer to recover. If a well is purged dry or recovery exceeds one hour, collect a sample as soon as the well has recharged to approximately 80% of its pre-purge volume, when practical (ADEC, 2019).

3.4.2 Surface Water Parameters

Water quality measurements should be taken when collecting surface water samples. Additional parameters (stream discharge rate, salinity, etc.) may be necessary when collecting surface water samples (ADEC, 2019). Section 8.0 of the ADEC *Field Sampling Guidance* (2019) contains additional information for surface water sampling and parameter collection.

4.0 DATA AND RECORD MANAGEMENT

The *Multi-Parameter Calibration Log* (Attachment 1) and the *Turbidimeter Bump Check Log* (Attachment 2) are intended for use in the field during groundwater sampling and monitoring well development activities. Complete these datasheets according to this SOP and the *Logbook Documentation and Field Notes* (BE-SOP-01).

5.0 REFERENCES

ADEC. 2019. *Field Sampling Guidance*. October.

ASTM. 2018. *Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations.* D6771. West Conshohocken, Pennsylvania. September.

Hach Company. 2017. *Hach 2100Q and 2100Qis User Manual. December.*

In-Situ. 2020. *Aqua TROLL 500 Multiparameter Sonde Operator's Manual. November*

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

Attachments

Attachment 1 Multi-Parameter Calibration Log
Attachment 2 Turbidimeter Bump Check Log
Attachment 3 YSI 556 Operation's Manual
Attachment 4 Aqua TROLL 500 Operator's Manual
Attachment 5 Hach 2100Q User Manual

Attachment 1
Multi-Parameter Calibration Log

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Multi-Parameter Calibration Log

Project Name/Location:____

Project Number:____

Equipment Make and Model(s):____________________________ & ________________________________

Serial Number(s): ____________________________________ & ________________________________

Serial Num.	Date	Temp.	pH (3 pt.)		Cond. (us/cm)		ORP (mV)		DO (100%)		Initials
			Standard	Reading	Standard	Reading	Standard	Reading	Atm. Press. (mmHg)	Reading (%)	

Serial Num.	Date	Temp.	pH (3 pt.)		Cond. (us/cm)		ORP (mV)		DO (100%)		Initials
			Standard	Reading	Standard	Reading	Standard	Reading	Atm. Press. (mmHg)	Reading (%)	

Attachment 2

Turbidimeter Bump Check Log

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Turbidity Meter Calibration Verification Check

Project Name/Location: ____________________

Project Number: ____________________

Equipment Make and Model(s): ____________________ & ____________________

Date	Time	Serial #:			Serial #:			Initials
		_____NTU	_____NTU	_____NTU	_____NTU	_____NTU	_____NTU	

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Attachment 3

YSI 556 Operation Manual

(on CD)

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Attachment 4

Aqua TROLL 600 Operator's Manual

(on CD)

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Attachment 5

Hach 2100Q User Manual

(on CD)

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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), depth to product (DTP), 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*.

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 piezometers 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-foot screen, pull the well out 10 feet).
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

Alaska Department of Environmental Conservation (ADEC). 2013. *Monitoring Well Guidance.* September.

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

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

U.S. Environmental Protection Agency (EPA). 1991. *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells.* Office of Research and Development.

EPA, Region 4. 2008. *Design and Installation of Monitoring Wells, Science and Ecosystem Support Division.* February.

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 ______

Record of Well Construction

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 procedures that will 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. After determining an 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 support base 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.

It is important to identify when materials require lifting equipment, such as slings and chokers, and to determine the proper equipment to assist in lifting the object 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) applies to all individuals operating motorized vehicles for work.

2.0 DRIVER SAFETY AND POLICIES

Statistics show that many accidents involve 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

The following policies are applicable to company vehicles:

- Company vehicles are for company business only and must be driven by active employees (unless permission is given by a supervisor) who are appropriately licensed, certified, and/or trained for the vehicle that they are operating.
- Vehicles must be maintained in good operating condition. A vehicle inspection form should be completed daily for vehicles used on project sites. Any noted deficiencies should be corrected as soon as possible.
- Drivers must conduct a complete safety walk-around prior to entering the vehicle.
- Occupants must 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

Company site personnel and subcontractors are required to immediately report all incidents or near misses to their immediate supervisor, SSHO, and/or Site Superintendent. The SSHO/Site Superintendent will evaluate the incident, determine if an emergency exists, and direct response activities as necessary.

If necessary, injured workers will be accompanied to the medical facility by the SSHO or Project Manager for proper case management.

After rendering first aid or summoning emergency services and securing the accident scene, all accidents will be immediately reported as required by the SSHO or Site Superintendent to the Company Project Manager and Company Safety Manager, who will then contact applicable Client Representatives, security personnel, law enforcement or any other involved parties.

The SSHO/Superintendent will then complete and submit an Initial Notice of Incident (and Immediate Report of Accident USACE Form POD 265 for USACE projects) to the Company Safety Manager, Project Manager, and USACE or client representatives within 24-hours of any incident or near miss.

STANDARD OPERATING PROCEDURE

BE-SOP-59

Site Traffic

1.0 INTRODUCTION

This standard operating procedure (SOP) applies to 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 also applies to 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 required:

- 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 should 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; and
- 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.