2021 Groundwater Monitoring Program

Work Plan

Kenai Peninsula Sites

Alaska

Swanson River Field Tank Settings

Kenai, Alaska

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ACRONYMS AND ABBREVIATIONS

~	approximately
°	degrees
°C	degrees Celsius
‘	feet
“	inches
>	greater than
<	less than
%	percent
(C)	cell
(O)	office
µg/L	micrograms per liter
µS/cm	microSiemens per centimeter
±	plus or minus
AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
AK	Alaska Method
BESC	Brice Environmental Services Corporation
bgs	below ground surface
Brice	Brice Engineering, LLC
BTEX	benzene, toluene, ethylbenzene, and xylenes
btoc	below top-of-casing
DO	dissolved oxygen
DRO	diesel-range organics
E&P	exploration and production
EPA	United States Environmental Protection Agency
G&I	Grind and Inject
GAC	granular activated carbon
GRO	gasoline-range organics
HC	hydrocarbon
HCl	hydrochloric acid
Hilcorp	Hilcorp Alaska, LLC
IDW	investigation-derived waste
LNAPL	light non-aqueous phase liquid
mg/L	milligrams per liter
mL	milliliters
MS/MSD	matrix spike/matrix spike duplicate
mV	millivolts
NAVD88	North American Vertical Datum of 1988
NTU	nephelometric turbidity units
Oil Risk	Oil Risk Consultants
ORP	oxidation reduction potential
PAH	polycyclic aromatic hydrocarbon
POL	petroleum, oil, and lubricant
PPE	personal protective equipment
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
QA/QC	quality assurance/quality control
SDS	safety data sheet
SLR	SLR International Corporation

ACRONYMS AND ABBREVIATIONS (continued)

SOP	standard operating procedures
SRF	Swanson River Field
TLC	Teflon-lined cap
TLS	Teflon-lined septa
TS	Tank Setting
TSCA	Toxic Substances Control Act
VOA	volatile organic analysis
VOC	volatile organic compound

1.0 INTRODUCTION

Brice Engineering, LLC (Brice) personnel will mobilize to the Kenai Peninsula to conduct biennial groundwater monitoring activities at the Hilcorp Alaska, LLC (Hilcorp) Swanson River Field (SRF) in the Kenai Peninsula. Figures 1 and 2 (Appendix A) present the sites where groundwater monitoring activities will take place. The SRF project area includes seven Tank Settings (TS) TS 1-4, TS 1-9, TS 1-27, TS 1-33, TS 2-15, TS 3-4, and TS 3-9.

1.1 Purpose and Organization of Report

This Work Plan describes the 2021 groundwater monitoring activities to be performed at seven contaminated sites within the SRF. Groundwater monitoring well survey, installation, and decommissioning activities at SRF are also described in this 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 the 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 the seven TS locations, including site conditions and analytical requirements.
- Section 5.0 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 the 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 SRF Health and Safety representative to complete site orientation and Wildlife Interaction Avoidance Plan requirements. Field personnel will also coordinate with the Hilcorp SRF Foreman and Lead Operators to communicate work areas and schedule and 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
John Coston	Hilcorp	SRF Health and Safety	907.776.6726 (O) 907.227.3189 (C)	jcoston@hilcorp.com

Table 1-1: Key Personnel (continued)

Name	Organization	Title	Phone Number	Email
Bruce Hershberger	Hilcorp	SRF Foreman	907.283.2541	bhershberger@hilcorp.com
Taylor Malone / Zack Rohr	Hilcorp	SRF Lead Operators	907.283.2543	tmalone@hilcorp.com / zrohr@hilcorp.com
Kimi Lloyd	Brice	Project Manager	907.275.2906 (O) 907.317.7999 (C)	klloyd@briceeng.com
Nicole Mattice	Brice	Geological Engineer / Field Lead	907.243.4509 (O) 970.301.6960 (C)	nmattice@briceeng.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	Regulatory Specialist	907.262.3412	peter.campbell@alaska.gov

Notes:
For definitions, see the Acronyms section.

1.3 Summary of Sites

Table 1-2 summarizes the contaminated sites included in the 2021 groundwater sampling effort.

Table 1-2: Swanson River Field 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	Wells to be Decommissioned	Wells to be Installed
SRF TS 1-4	8	2334.38.018	441	6	7	2	1	1
SRF TS 1-9	12	2334.38.019	448	6	12	3	0	0
SRF TS 1-27	7	2334.38.020	442	4	7	0	0	0
SRF TS 1-33	12	2334.38.021	443	6	12	0	2	0
SRF TS 2-15	5	2334.38.022	444	1	5	0	0	0
SRF TS 3-4	12	2334.38.023	445	6	12	2	0	0
SRF TS 3-9	14	2334.38.024	446	8	14	2	0	0

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

1.4 Regulatory Criteria

Groundwater analytical results will be evaluated against the ADEC levels presented in Title 18 of the Alaska Administrative Code (AAC), Chapter 75, Section 345 (18 AAC 75.345), Table C (ADEC 2020). In 2017, petroleum-related volatile organic compounds (VOCs) (including BTEX) and polycyclic aromatic hydrocarbons (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 2017). 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 groundwater 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 PAH analytes from the sampling suite where observed well concentrations are either non-detect or less than 20 percent (%) of ADEC cleanup levels in two consecutive sampling events. Current ADEC Table C groundwater cleanup levels are presented below in Table 1-3.

Table 1-3: ADEC Table C Groundwater Cleanup Levels

Analyte	ADEC Cleanup Level[1] [µg/L]
Ethylene glycol	40,000
POL	
DRO	1,500
GRO	2,200
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
PAHs	
1-Methylnaphthalene	11
2-Methylnaphthalene	36
Acenaphthene	530
Acenaphthylene	260
Anthracene	43
Benz[a]anthracene	0.3
Benzo[a]pyrene	0.25
Benzo[b]fluoranthene	2.5
Benzo[g,h,i]perylene	0.26
Benzo[k]fluoranthene	0.8
Chrysene	2
Dibenz[a,h]anthracene	0.25
Fluoranthene	260
Fluorene	290
Indeno[1,2,3-cd]pyrene	0.19
Naphthalene	1.7
Phenanthrene	170
Pyrene	120

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

[1] Groundwater levels as defined by 18 AAC 75.345, Table C (ADEC 2020).

1.5 Schedule Summary

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

Table 1-4: Project Schedule

Activity	Deliverable Submittal Date / Deadline
Final Work Plan	06/09/2021
Field work	6/22/2021 to 7/23/2021
Reporting	8/12/2021 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 250 Hospital Pl Soldotna, Alaska 99669	907.714.4404
Fire	KBP Central Emergency Services Station 3 35218 Sterling Hwy Sterling, Alaska 99672	907.714.2443
Police	Soldotna Police Department 44510 Sterling Hwy Soldotna, Alaska 99669	907.262.4455

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 will 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 will 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, and 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 potential wildlife attractants.

2.2.4 Chemical Hazards

Personnel may be exposed to petroleum, oil, and lubricant (POL)-related contaminants such as diesel-range organics (DRO); gasoline-range organics (GRO); residual-range organics; benzene, toluene, ethylbenzene, and xylenes (BTEX); VOCs; and PAHs. 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;
- Monitoring well decommissioning, installation, development, and survey (as necessary);
- Collection of groundwater samples;
- Sample handling and chain-of-custody;
- Decontamination of sampling equipment;
- Waste management; and
- Field documentation.

3.1 Monitoring Well Inspection and Maintenance

Monitoring wells will be inspected, including the outer monument casing, 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 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, 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 the Brice Standard Operating Procedure BE-SOP-21 *Groundwater and LNAPL Measurements* (Appendix B).

3.3 Monitoring Well Decommissioning, Installation, and Development

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

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

3.4 Analytical Sampling

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

3.4.1 Groundwater Sampling Procedures

Groundwater samples will be collected from wells in accordance with low-flow sampling procedures based on United States Environmental Protection Agency (EPA) guidance (EPA 2017) and the ADEC Field Sampling Guidance (ADEC 2017) 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 HydraSleeve. Wells exhibiting biological infiltration will be redeveloped prior to sampling.

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

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

Water quality parameters will be considered stable when three successive readings, collected 3-5 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 ±1 NTU	0.3 to > 900
ORP	mV	1	±10 mV	-120 to 350
DO	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 2017).
Only three parameters are required to stabilize, four when using temperature.

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

Table 3-2: Summary of Groundwater Analyses

Parameter	Method	Container Description	Preservation / Holding Time
DRO	AK102	(2) 250 mL amber glass jar, TLC	HCl preservative, 0 to 6°C 14 days to extraction, 40 days to analysis
GRO	AK101	(3) 40 mL VOA vials, TLS	HCl preservative, 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

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

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 2017). 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 Quality Assurance/Quality Control

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/matrix spike duplicate (MS/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 and petroleum-related VOCs by SW8260C).

These QA/QC sampling frequencies will be applied to each site individually; field duplicate and MS/MSD samples will not be shared between the sites described in Section 4.0. Appropriate wells for duplicate and MS/MSD sample collection will be 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.

3.4.3 Sample Identification

The sample identification nomenclature for this project is defined below:

- The first set of characters identify the site
  - SRF14 represents SRF TS 1-4
  - SRF19 represents SRF TS 1-9
  - SRF127 represents SRF TS 1-27
  - SRF133 represents SRF TS 1-33
  - SRF215 represents SRF TS 2-15
  - SRF34 represents SRF TS 3-4
  - SRF39 represents SRF TS 3-9
- The second set of characters identifies the well
  - e.g. MW4 identifies well MW-4
- The third set of characters identifies the month and year that the sample was collected
  - e.g. 0621 indicates June 2021

For example, a sample collected in June 2021 from well TS1-27L at the SRF Tank Setting 1-27 site would be labeled "SRF127-TS127L-0621." 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 "SRF127-TS127LZ-0621".

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* 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 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 over the GAC filtration unit and allowed to drain into 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 a sheen is observed in the treated water, the water will be poured over the GAC and treated up to three times until a sheen is not observed. If a sheen persists after three treatment cycles, the water will be segregated, labeled, and stored in the Hilcorp SRF Grind and Inject (G&I) Waste Storage Facility 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 (e.g., 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*. Daily reports will also be provided to summarize daily activities and overall project progress. Field documentation will be appended to the final report.

3.9 Reporting and Documentation

After the 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 and groundwater contour models;
- Supporting field documentation;
- A sample summary;
- Laboratory data;
- A photographic log; and
- Conclusions and recommendations.

A single draft report detailing each of the eight sites will be prepared and provided to Hilcorp for comments. Comments will be incorporated into a final report version for submittal to ADEC and inclusion in the administrative record.

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Table 3-3: Anticipated Waste Streams

Waste Stream	Waste Classification	Estimated Quantity	Container	Proper Shipping Name	Disposal	Notes
Liquid IDW - No odor/sheen (Purge water, decon water)	Non-TSCA/RCRA regulated	400 gallons	55-gallon drum	Nonhazardous 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 IDW - TS1-4 (Purge water, decon water from sites)	Non-exempt, ethylene glycol (Site TS 1-4)	50 gallons	55-gallon drum	Nonhazardous liquid (impacted with ethylene glycol)	Hilcorp	Purge water from SRF TS 1-4 is impacted with ethylene glycol, which does not readily adsorb to activated carbon. This is non-exempt waste and will be containerized in 55-gallon drums, labeled, recorded on the SRF G&I Waste Log, and transferred to Hilcorp SRF G&I Facility for storage and subsequent disposal.
Liquid IDW - Odor/sheen (Purge water, decon water)	Non-exempt (Sites TS 1-27, and TS 2-15)	0 gallons	55-gallon drum	Nonhazardous liquid (Hydrocarbon odor and/or sheen)	Hilcorp	GAC is anticipated to be sufficient treatment; 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 SRF G&I Waste Log, and transferred to Hilcorp SRF G&I Facility for storage and subsequent disposal. SRF Sites TS 1-4, TS 1-27, and TS 2-15 are not exploration and production (E&P) exempt.
Liquid IDW - Odor/sheen (Purge water, decon water)	Exempt (all other SRF TS sites)	0 gallons	55-gallon drum	Nonhazardous liquid (Hydrocarbon odor and/or sheen)	Hilcorp	GAC is anticipated to be sufficient treatment; 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 SRF G&I Waste Log, and transferred to Hilcorp SRF G&I Facility for storage and subsequent disposal. The remaining SRF TS sites have sources relating to E&P and are, therefore, exempt.
Drilling Waste Soils	Exempt	<1 cy	55-gallon drum	Nonhazardous solid (Hydrocarbon odor and/or staining)	Hilcorp	Soils unearthed during drilling activities will be placed downhole at the point of generation to the maximum extent practicable. Where there are no indications of contamination by visual, olfactory, or PID observation, excess soils that cannot be placed downhole will be land spread 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 SRF G&I Waste Log, and transferred to Hilcorp SRF G&I Facility for storage and subsequent disposal.
LNAPL	Not Applicable	<5 gallons	5-gal bucket with screw-top lid	Not Applicable	Recycle	Document volume and transfer to Hilcorp or combine with Hilcorp Waste Oil Drums, located inside each Tank Setting building, for recycle.
LNAPL-absorbent socks	Non-TSCA/RCRA regulated	5 "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 TS 1-4, TS 1-9, TS 1-33, TS 3-4, and TS 3-9. Bags will be segregated by site, labeled (TS 1-4 socks will also be identified to contain ethylene glycol), recorded on the SRF G&I Waste Log, and transferred to Hilcorp SRF G&I Facility for storage and subsequent disposal.
Solid Waste	Non-TSCA/RCRA regulated	15 bags	Heavy 42-gal garbage bags	Nonhazardous 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 dumpsters at SRF in which general refuse can be placed.
Spent GAC	Non-TSCA/RCRA regulated	55 gallons	55-gallon drum	Nonhazardous 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 SRF TANK SETTINGS SITE-SPECIFIC INFORMATION

SRF is located at Milepost 17.5 outside of Sterling, Alaska, on a 12-square-mile parcel of land leased from the United States Fish and Wildlife Service within the boundaries of the Kenai National Wildlife Refuge (Figure 1). SRF is also a Bureau of Land Management-managed oil and gas unit. Hilcorp took over the lease and operations of the facility from Union Oil Company of California in 2012.

Monitoring well installation at the SRF Tank Settings began in 1989, following investigations of contaminated soil at each site. By 1990, 53 monitoring wells were installed across the seven tank settings, focusing on hydrocarbon-based contaminants. In 2002, an additional 23 monitoring wells were installed based on groundwater monitoring results. Monitoring wells were generally installed around each tank setting and within flare pits to monitor potential releases. Monitoring wells are generally 2-inch diameter PVC risers with 10-foot screened intervals ranging in depth from approximately 16 to 49 feet below ground surface (bgs) and protected by aboveground metal monuments (SLR International Corporation [SLR] 2015).

The following subsections detail the SRF TS sites, sampling requirements, and analyses. Appendix A includes the figures presenting the sites and well locations.

4.1 SRF TS 1-4

TS 1-4 is located centrally in SRF (Figure 2). The following subsections include site-specific information about site geology and hydrogeology, previous investigations and groundwater monitoring, well maintenance summary, and planned 2021 groundwater monitoring activities at TS 1-4.

4.1.1 TS 1-4 Geology and Hydrogeology

The elevation of the water table at TS 1-4 varies from approximately 125 to 145 feet (relative to the North American Vertical Datum of 1988 [NAVD88]). Groundwater at TS 1-4 has historically been observed to generally flow to the north during summer/fall sampling events. Groundwater flow direction was determined to be north-northeast in 2015 (BESC 2016a), north in 2017 (BESC 2019b), and northwest in 2019 (BESC 2019a).

4.1.2 TS 1-4 Previous Investigation and Monitoring Activities

Five groundwater monitoring wells were installed by 1990 at TS 1-4 and three additional monitoring wells were installed in 2002. From 2000 to 2010, the groundwater monitoring wells were sampled for BTEX on an annual basis. Between 2011 and 2013, groundwater monitoring did not occur, but monitoring resumed in 2014. Benzene concentrations have consistently exceeded the ADEC Table C groundwater cleanup level in samples collected from monitoring wells TS1-4F, TS1-4G, TS1-4J, and FS1-4E. LNAPL has previously been observed in wells TS1-4F, TS1-4G, and TS1-4J during previous sampling events. During previous sampling events, results for all BTEX analytes in samples from monitoring wells TS1-4CC and TS1-4DD have been either non-detect or below the ADEC Table C groundwater cleanup levels.

In 2015, the site was moved to a biennial sampling basis and ethylene glycol was added to the analytical suite following a 26 September release of approximately 1,600 gallons of a 50/50 mixture of ethylene glycol and water from a corroded pipeline under the oil line heater located near TS1-4G. Sample results for monitoring wells TS1-4F and FS1-4E exceeded the ADEC Table C groundwater cleanup level for benzene. Monitoring well TS1-4J contained measurable LNAPL during the 2015 event (BESC 2016a).

In 2017, monitoring wells TS1-4EE, TS1-4GR, FS1-4E, and FS1-4H were sampled for petroleum-related VOCs (including BTEX) and PAH. In addition, monitoring wells TS1-4EE and TS1-4GR were sampled for ethylene glycol. Monitoring wells TS1-4F and TS1-4J were not sampled due to the presence of LNAPL. Absorbent socks were flipped, and product was bailed from TS1-4J. Groundwater collected from new well TS1-4GR had persistent soapy bubbles that made it difficult to eliminate headspace entirely from the volatile organic analysis (VOA) vials. It is likely that the bubbles resulted from a reaction of the acid preservative in the sample container with ethylene glycol present in the well. In monitoring wells FS1-4E and FS1-4H, concentrations of benzene, ethylbenzene, and naphthalene exceeded ADEC Table C groundwater cleanup levels. In monitoring well TS1-4GR, concentrations of 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, xylenes, ethylene glycol, 1-methylnaphthalene, and naphthalene exceeded ADEC Table C groundwater cleanup levels. Contaminant concentrations were observed to be generally consistent with historical observations, except for the detection of LNAPL in TS1-4F. One replacement well was installed at TS 1-4. Well TS1-4G was replaced with TS1-4GR, approximately 5 feet from the original location. The water collected from new monitoring well TS1-4GR had a distinct odor (not a hydrocarbon odor) and was tinted yellow-brown, indicative of an ethylene glycol presence. During development of this well, recharge was extremely slow, possibly a result of very fine-grained soil in the vicinity of the well (BESC 2019b).

In 2019, monitoring wells FS1-4E, FS1-4H, TS1-4EE, and TS1-4GR were sampled for petroleum-related VOCs (including BTEX) and PAH. Wells TS1-4EE and TS1-4GR were also sampled for ethylene glycol. Wells TS1-4F and TS1-4J were not sampled due to the presence of LNAPL, in which the absorbent socks were replaced. Groundwater monitoring results indicated concentrations of 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, naphthalene, xylenes, 1-methylnaphthalene, 2-methylnaphthalene, and ethylene glycol above ADEC Table C groundwater cleanup levels among wells FS1-4E, FS1-4H, and TS1-4GR. Results for all other analytes were either non-detect or were detected below ADEC Table C groundwater cleanup levels. Contaminant concentrations were observed to be generally consistent with historical observations. TS1-4GR exhibited a strong non-petroleum, oil, and lubricant (POL) odor, and its purge water exhibited a tinted pale-orange color, suspected to be glycol. Wells FS1-4E and FS1-4H were confirmed to have 10-foot screens, the TS1-4CC riser was confirmed to be sheared, and the TS1-4EE riser was confirmed to be in good condition (BESC 2019a).

4.1.3 TS 1-4 2021 Monitoring Well Inspections and Maintenance

All TS 1-4 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 TS 1-4.

Table 4-1: SRF TS 1-4 Well Maintenance Summary

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
TS1-4CC	Damaged				-	2”	To be decommissioned; sheared PVC ~ 4.39’ btoc and monument casing bent ~25° angle.
TS1-4DD	Fair	X			5.69	2”	
TS1-4EE	Good				6.30	2”	10’ screen.

Table 4-3: SRF TS 1-4 Well Maintenance Summary (continued)

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
TS1-4F	Good		X	X	11.15	2”	Replace sock if LNAPL present.
TS1-4GR	Good			X	14.45	2”	Distinct/potent glycol odor. Remove sock if LNAPL is absent. 10’ screen.
TS1-4J	Altered		X	X	10.20	2”	No measurable product. Replace sock if LNAPL present.
FS1-4E	Fair				9.33	2”	10’ screen.
FS1-4H	Fair	X			14.27	2”	10’ screen.
FS1-4I	Additional well to be installed downgradient of flare pit.						

Notes:
For definitions, see 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.

4.1.4 TS 1-4 2021 Groundwater Monitoring Activities

SRF TS 1-4 groundwater wells are monitored on a biennial schedule. All viable wells are gauged during each sampling event. The planned field activities for groundwater monitoring at TS 1-4 are summarized below:

- The vegetation at and surrounding TS 1-4 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 viable TS 1-4 monitoring wells within a 2-hour period in order to determine groundwater elevation and flow direction.
- TS1-4F and TS1-4J: Monitor and remove LNAPL and replace absorbent socks. If LNAPL is not observed, sample well for petroleum-related VOCs (including BTEX) and PAHs.
- FS1-4E, and FS1-4H: Sample monitoring wells associated with the flare pit for 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, cumene, naphthalene, xylenes, 1-methylnaphthalene, and 2-methylnaphthalene
- TS1-4EE and TS1-4GR: Sample for ethylene glycol, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, cumene, naphthalene, xylenes, 1-methylnaphthalene, and 2-methylnaphthalene. These wells are downgradient of monitoring wells TS1-4F and TS1-4J, which contain LNAPL.
- FS1-4I: Install (decommission/installation activities completed under a separate work plan). Well TS1-4I will be downgradient (north) of the flare pit to bound the potential contaminant source (flare pit).
- TS1-4CC: Decommission (decommission/installation activities completed under a separate work plan). Well TS1-4CC was previously damaged and is inaccessible.
- Resurvey all TS 1-4 wells during decommission/installation activities completed under a separate work plan to determine top of casing elevations.

Table 4-4 identifies the TS 1-4 wells and sample analyses. Monitoring well locations are presented on Figure 3.

Table 4-2: SRF TS 1-4 Summary of Monitoring Wells and 2021 Analyses

WELL ID	GAUGE	ANALYSES / METHOD				
		SW8260C		SW8270SIM		SW8015C
		VOCs[1]	Select VOCs[2]	PAH[1]	Select PAH[3]	Ethylene Glycol
TS1-4DD	X					
TS1-4EE	X		X		X	X
TS1-4F	X	X		X		
TS1-4GR	X		X		X	X
TS1-4J	X	X		X		
FS1-4H	X		X		X	
FS1-4E	X		X		X	

Notes:
For definitions, see 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, ethylbenzene, cumene, and xylenes.
3 PAH analytes reduced in 2019 to include only naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene.

4.2 SRF TS 1-9

TS 1-9 is located approximately a mile south of TS 1-4 (Figure 2). 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 TS 1-9.

4.2.1 TS 1-9 Geology and Hydrogeology

Groundwater at TS 1-9 has historically been observed to flow west-northwest, except for 2015 results indicating that groundwater flowed southwest (BESC 2016b). In 2019, groundwater was observed to flow northwest, generally consistent with historical observations.

The groundwater elevation is approximately 114 feet relative to the NAVD88, and the historically observed potentiometric surface is very nearly flat (Oil Risk Consultants [Oil Risk] 2011; SLR 2015; BESC 2016b, 2019b). Based on 2019 observations, the groundwater table was found to be very nearly flat and the groundwater elevation ranged from 113.19 feet to 115.08 feet (NAVD88), consistent with historical observations. Groundwater elevation at TS1-9II was omitted from groundwater modeling due to an anomalous reading. The 2015 groundwater elevations and modeling results (BESC 2016b) were also omitted from the evaluation because the results appear to be anomalous in comparison to the findings from 2019, 2017, 2014, and 2010 (BESC 2019a, 2019b, 2016b; SLR 2015; Oil Risk 2011).

4.2.2 TS 1-9 Previous Investigation and Monitoring Activities

Ten monitoring wells were installed by 1990, and two additional monitoring wells, TS1-9HH and TS1-9II, were installed in 2002. The groundwater monitoring wells at TS 1-9 were sampled for BTEX on an annual basis from 2000 to 2010. Between 2011 and 2013, groundwater monitoring did not occur, but monitoring resumed in 2014. The site was moved to a periodic sampling basis in 2015 with the site wells split between two sampling frequencies, biennial and every 4 years.

Concentrations of BTEX analytes have exceeded the ADEC Table C groundwater cleanup levels in historical samples from monitoring wells TS1-9A, TS1-9B, TS1-9C, TS1-9D, FS1-9F, and FS1-9N. Monitoring well TS1-9U exhibited concentrations of BTEX analytes exceeding ADEC Table C groundwater cleanup levels from 2000 to 2005 and in 2009; however, all BTEX concentrations in this monitoring well have been non-detect or below ADEC Table C groundwater cleanup levels since 2010. TS1-9U is sampled every 4 years.

Since 2013, results for all BTEX analytes in samples from monitoring wells TS1-9HH, TS1-9II, FS1-9D, FS1-9I, and FS1-9M have been non-detect or below ADEC Table C groundwater cleanup levels. LNAPL has been detected in TS1-9B, TS1-9C, TS1-9D, and FS1-9F during previous sampling events (BESC 2016b).

In 2017, monitoring wells TS1-9A, TS1-9C, and FS1-9N were sampled for petroleum-related VOCs (including BTEX) and PAH. Concentrations of 1,2,4-trimethylbenzene, benzene, ethylbenzene, naphthalene, xylenes, and 1-methylnaphthalene were detected above ADEC Table C groundwater cleanup levels among all three wells. Some additional PAH analytes, though non-detect, had reporting limits exceeding ADEC Table C groundwater cleanup levels. Monitoring wells TS1-9B, TS1-9D, and FS1-9F contained product and were not sampled. No measurable product was found in TS1-9B, but many globules of product were observed on the interface probe after gauging. Sorbent socks were installed or replaced, and approximately 200 milliliters of product was removed from FS1-9F (BESC 2019b).

In 2019, monitoring wells TS1-9C, TS1-9D, TS1-9HH, TS1-9U, FS1-9D, FS1-9I, FS1-9M, and FS1-9N were sampled for petroleum-related VOCs (including BTEX) and PAH. Wells TS1-9A, TS1-9B, and FS1-9F were not sampled due to LNAPL detection. LNAPL has not historically been detected in TS1-9A, but traces of product were observed on the interface probe after gauging activities. No measurable product was detected in TS1-9B; however, traces of product were detected on the oil-water interface probe, and this well has historically had LNAPL detections. Product was measured to be approximately 0.05 foot in FS1-9F, and only traces of product were removed during product recovery efforts. Absorbent socks were placed or replaced in all three wells. Concentrations of 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, naphthalene, xylenes, and 1-methylnaphthalene exceeded ADEC Table C groundwater cleanup levels among wells TS1-9C, TS1-9D, TS1-9U, and FS1-9N. Results for all other analytes were either non-detect or were below ADEC Table C groundwater cleanup levels. Contaminant concentrations were observed to be generally consistent with historical observations. Additionally, 10-foot screens were confirmed for wells TS1-9C, TS1-9D, TS1-9U, FS1-9D, FS1-9I, FS1-9M, and FS1-9N. All wells were in generally good condition and required little maintenance during inspection and maintenance activities (BESC 2019a).

4.2.3 TS 1-9 2021 Monitoring Well Inspections and Maintenance

All TS 1-9 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 4-5 includes a well maintenance summary for TS 1-9.

Table 4-3: SRF TS 1-9 Well Maintenance Summary

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
TS1-9A	Fair		X	X	22.73	2”	Replace sock if LNAPL present.
TS1-9B	Good		X	X	22.31	2”	Replace sock if LNAPL present.
TS1-9C	Good				22.61	2”	Product on casing, bailer in monument. No LNAPL detected in well in 2019. Replace sock if LNAPL present. 10’ screen.
TS1-9D	Good		X	X	21.91	2”	Replace sock if LNAPL present. 10’ screen.
TS1-9U	Good				23.87	2”	10’ screen.
TS1-9HH	Fair	X			20.92	2”	10’ screen.
TS1-9II	Good				12.36	2”	
FS1-9D	Good				14.03	2”	5’ screen.
FS1-9F	Fair		X	X	12.69	2”	Replace sock if LNAPL present.
FS1-9I	Good				13.70	2”	10’ screen.
FS1-9M	Good				20.52	2”	10’ screen.
FS1-9N	Good	X			17.03	2”	10’ screen.

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

4.2.4 TS 1-9 2021 Groundwater Monitoring Activities

TS 1-9 groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. The planned field activities for groundwater monitoring at TS 1-9 are summarized below:

- The vegetation at and surrounding TS 1-9 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.
- TS1-9A, TS1-9B, and FS1-9F: Monitor and remove LNAPL and replace absorbent socks. If LNAPL is not observed, sample wells for petroleum-related VOCs (including BTEX) and PAHs.
- TS1-9C, TS1-9D, and FS1-9N: Sample for petroleum-related VOCs (including BTEX), and PAHs.
- TS1-9U, TS1-9HH, FS1-9D, FS1-9I, and FS1-9M: Sample for petroleum-related VOCs (including BTEX) and PAHs at a frequency of every four years. These wells are scheduled to be sampled in 2023.
- Resurvey all TS 1-9 wells during decommission/installation activities completed under a separate work plan to determine top of casing elevations.

Table 4-6 identifies the TS 1-9 wells and sample analyses. Monitoring well locations are presented on Figure 4.

Table 4-4: SRF TS 1-9 Summary of Monitoring Wells and 2021 Analyses

WELL ID	GAUGE	ANALYSES / METHOD	
		SW8260C	SW8270SIM
		VOCs[1]	PAH[1]
TS1-9A	X	X	X
TS1-9B	X	X	X
TS1-9C	X	X	X
TS1-9D	X	X	X
TS1-9HH	X		
TS1-9II	X		
TS1-9U	X		
FS1-9D	X		
FS1-9F	X	X	X
FS1-9I	X		
FS1-9M	X		
FS1-9N	X	X	X

Notes:
For definitions, see 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.

4.3 SRF TS 1-27

The SRF TS 1-27 is located approximately 2.5 miles northeast of TS 1-4 (Figure 2). 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 SRF TS 1-27.

4.3.1 TS 1-27 Geology and Hydrogeology

Groundwater at TS 1-27 has historically been observed to flow to the west-southwest during summer/fall sampling events, and the groundwater elevation is approximately 245 feet relative to the NAVD88 (BESC 2016c, 2019b). In 2019, Groundwater elevations at TS 1-27 ranged between 241.54 feet and 252.33 feet (NAVD88), and the estimated direction of groundwater flow was west-southwest, which is consistent with historical observations (BESC 2019a).

4.3.2 TS 1-27 Previous Investigation and Monitoring Activities

Four monitoring wells (TS1-27G, TS1-27J, TS1-27K, and FS1-27C) were installed by 1990 at TS 1-27, and the remaining three wells, TS1-27L, TS1-27M, and TS1-27N, were installed in 2002.The groundwater monitoring wells were sampled for BTEX on an annual basis from 2000 to 2010. Between 2011 and 2013, groundwater monitoring did not occur, but monitoring resumed in 2014. The site was moved to a periodic sampling basis in 2015 with the site wells split between two sampling frequencies, biennial and every 4 years.

Benzene, ethylbenzene, and xylenes have exceeded the ADEC Table C groundwater cleanup levels since 2000 in wells TS1-27G, TS1-27J, TS1-27K, TS1-27L, and TS1-27M. Analytical results in wells TS1-27N and FS1-27C have consistently been non-detect. LNAPL has not been measured in any of the monitoring wells at TS 1-27 (SLR 2015; BESC 2016c).

In 2017, wells TS1-27G, TS1-27K, TS1-27L, and TS1-27M were sampled for petroleum-related VOCs (including BTEX), and PAHs. Concentrations of 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, naphthalene, xylenes, and 1-methylnaphthalene exceeded the ADEC Table C groundwater cleanup levels in monitoring wells TS1-27G, TS1-27K, TS1-27L, and TS1-27M. Results for all other analytes were either non-detect or below the ADEC Table C groundwater cleanup levels. Some additional PAH analytes had non-detect results with reporting limits exceeding ADEC Table C groundwater cleanup levels. Contaminant concentrations were observed to be consistent with historical observations; however, concentrations of benzene, ethylbenzene, and xylenes were elevated in well TS1-27G in 2015 and 2017, which had previously exhibited concentrations of all analytes below the ADEC Table C groundwater cleanup levels between 2009 and 2014. Since 2010, concentrations of naphthalene in downgradient well TS1-27M have been observed below the ADEC Table C groundwater cleanup level; 2017 analysis of naphthalene shows an exceedance by method SW8260C (3.77 micrograms per liter [µg/L]) but did not exceed when analyzed by method SW8270D SIM (0.823 µg/L). Gauging data from well FS1-27C was not used in groundwater contour modeling due to observed heaving (BESC 2019b).

In 2019, monitoring wells TS1-27G, TS1-27K, TS1-27L, TS1-27M, and FS1-27C were successfully sampled for petroleum-related VOCs (including BTEX) and PAH. Concentrations of 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, naphthalene, xylenes, 1-methylnaphthalene, and 2-methylnaphthalene exceeded ADEC Table C groundwater cleanup levels among wells TS1-27G, TS1-27K, TS1-27L, and TS1-27M. Results for all other analytes were either non-detect or were detected below ADEC Table C groundwater cleanup levels. Anomalous results were observed in well TS1-27L (contaminant concentrations appeared lower than historical results) and well TS1-27M (contaminant concentrations appeared higher than historical results). Evaluation of historical results from these wells indicates that collected samples may have accidentally been swapped or mislabeled. Contaminant concentrations for all other results were observed to be generally consistent with historical observations. Additionally, 10-foot screens were confirmed for wells TS1-27G, TS1-27K, and TS1-27L during inspection and maintenance activities (BESC 2019a).

4.3.3 TS 1-27 2021 Monitoring Well Inspections and Maintenance

All TS 1-27 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 4-7 includes a well maintenance summary for TS 1-27.

Table 4-5: SRF TS 1-27 Well Maintenance Summary

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
TS1-27G	Good				12.50	2”	10’ screen.
TS1-27J	Good				15.89	2”	HC odor in 2019.
TS1-27K	Good				13.24	2”	HC odor in 2019. 10’ screen.
TS1-27L	Good				15.62	2”	10’ screen.
TS1-27M	Good				13.93	2”	10’ screen.
TS1-27N	Good	X			24.40	2”	

Table 4-7: SRF TS 1-27 Well Maintenance Summary (continued)

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
FS1-27C	Good				10.69	2”	10’ screen.

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

4.3.4 TS 1-27 2021 Groundwater Monitoring Activities

TS 1-27 groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. The planned field activities for 2021 groundwater monitoring at TS 1-27 are summarized below:

- The vegetation at and surrounding TS 1-27 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.
- TS1-27G, TS1-27K, TS1-27L, and TS1-27M: Sample for 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, cumene, naphthalene, xylenes, 1-methylnaphthalene, and 2-methylnaphthalene.
- FS1-27C: Sample for petroleum-related VOCs (including BTEX) and PAHs at a frequency of every four years. This well is scheduled to be sampled in 2023.
- Resurvey all TS 1-27 wells during decommission/installation activities completed under a separate work plan to determine top of casing elevations.

Table 4-8 identifies the TS 1-27 wells and sample analyses. Monitoring well locations are presented on Figure 5.

Table 4-6: SRF TS 1-27 Summary of Monitoring Wells and 2021 Analyses

WELL ID	GAUGE	ANALYSES / METHOD			
		SW8260C		SW8270SIM	
		VOCs[1]	Select VOCs[2]	PAH[1]	Select PAH[3]
TS1-27G	X		X		X
TS1-27J	X				
TS1-27K	X		X		X
TS1-27L	X		X		X
TS1-27M	X		X		X
TS1-27N	X				
FS1-27C	X				

Notes:
For definitions, see Acronyms and Abbreviations section.
[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, cumene, and xylenes.
[3] PAH analytes reduced in 2019 to include only naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene.

4.4 SRF TS 1-33

TS 1-33 is located approximately one mile north of TS 1-4 (Figure 2). 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 TS 1-33.

4.4.1 TS 1-33 Geology and Hydrogeology

Groundwater at TS 1-33 has historically been observed to flow to the east-southeast during summer/fall sampling events, and the groundwater elevation is approximately 145 feet relative to the NAVD88 (SLR 2015; BESC 2016d, 2019b). In 2019, groundwater elevations at TS 1-33 ranged between 130.84 feet and 161.33 feet (NAVD88), and the estimated direction of groundwater flow was southeast, which is generally consistent with historical observations (BESC 2019a).

4.4.2 TS 1-33 Previous Investigation and Monitoring Activities

Eight monitoring wells were installed by 1990, four monitoring wells (TS1-33JJ, TS1-33KK, TS1-33O2, and FS1-33T) were installed in 2002, and two monitoring wells (TS1-33N and FS1-33W) were installed in 2017. The groundwater monitoring wells at TS 1-33 were sampled for BTEX on an annual basis from 2000 to 2010. Between 2011 and 2013, groundwater monitoring did not occur, but monitoring resumed in 2014. The site was moved to a periodic sampling basis in 2015 with the site wells split between two sampling frequencies, biennial and every 4 years.

Benzene, ethylbenzene, and xylenes detected in groundwater samples at TS 1-33 have exceeded ADEC Table C groundwater cleanup levels since 2000. Analytes consistently exhibiting concentrations above the ADEC Table C groundwater cleanup levels since 2000 include: benzene in samples collected from four monitoring wells (TS1-33Q, TS1-33O2, FS1-33F, and FS1-33H), ethylbenzene in samples collected from three monitoring wells (TS1-33Q, TS1-33O2, and FS1-33H), and xylenes in samples collected from one monitoring well (TS1-33Q). TS1-33U has also had consistent benzene exceedances, although this well has not been sampled since 2009 due to an obstruction. Ethylbenzene exceedances have occurred periodically in FS1-33R since 2000, but the well has not been sampled since 2014; FS1-33R was not located in 2017 and is assumed to be either decommissioned or destroyed.

Benzene concentrations have exceeded the ADEC Table C groundwater cleanup level occasionally in samples from five monitoring wells at TS 1-33; three times in samples collected from TS1-33KK (in 2002, 2003, and 2010), six times in samples collected from FS1-33O (as recently as 2014), five times in samples collected from FS1-33R (as recently as 2010), and five times in samples collected from FS1-33S (as recently as 2010). BTEX concentrations in samples collected from TS1-33JJ, TS1-33P, and FS1-33T have been non-detect or below the ADEC Table C groundwater cleanup levels since 2000. Measurable LNAPL has been observed in TS1-33U (2000, 2001, 2003, and 2005) and FS1-33H (2000-2003, 2014).

In 2017, concentrations of 1,2,4-trimethylbenze, 1,3,5-trimethylbenzene benzene, ethylbenzene, naphthalene, xylenes, and 1-methylnaphthalene exceeded ADEC Table C groundwater cleanup levels in monitoring wells FS1-33F, FS1-33H, TS1-33O2, and TS1-33Q. Monitoring well TS1-33U was replaced with monitoring well TS1-33UR, which was not sampled due to product presence in the well and in soil cuttings during installation. Well FS1-3R was scheduled for decommission but attempts to locate the well were unsuccessful due to either previously being decommissioned or destroyed, and was removed from the groundwater monitoring program. Monitoring well TS1-33N was newly installed upgradient, across the road to the northwest of the tanks setting, which accesses an artesian aquifer confined to a two-foot-thick sandy interval from about 24 to 26 feet bgs. Monitoring well FS1-33W was newly installed southeast of the flare pit and the Pad SRU 41-33, downgradient from FS1-33S and FS1-33H, which have historically had concentrations of VOCs in exceedance of ADEC Table C groundwater cleanup levels (BESC 2019b).

In 2019, wells TS1-33JJ, TS1-33O2, TS1-33Q, TS1-33UR, FS1-33F, FS1-33H, FS1-33S, and FS1-33W were sampled for petroleum-related VOCs (including BTEX) and PAHs. Groundwater well FS1-33W was moved to sampling once every 4 years in 2017 due to non-detect results for VOCs and PAH analytes; however, with the reincorporation of VOCs and PAH per ADEC request (ADEC 2019), samples were collected at FS1-33W in 2019. Well TS1-33UR was sampled for the first time since it was installed in 2017. Wells FS1-33F and TS1-33UR were sampled, and absorbent socks were replaced although no measurable product was observed. The PVC casing at FS1-33H was observed to be coated in product; therefore, PAH samples were collected using a peristaltic pump, and VOC samples were collected using a HydraSleeve to minimize compromising impacts to the reusable sampling equipment and cross-contamination. A peristaltic pump and HydraSleeve were also used at well FS1-33S to collect PAH and VOC samples, respectively, due to significant monument damage that prevented the use of a bladder pump. The PVC for FS1-33S was confirmed to be in good condition. A weak, intermittent signal in FS1-33O appeared to be a false signal in 2019, causing water measurement discrepancies in 2017. The downhole camera visually verified a wet, white, viscous residue lining the PVC casing at the same depth (approximately 17 feet btoc); the type and source of the residue could not be identified. Concentrations of 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, naphthalene, xylenes, and 1-methylnaphthalene exceeded ADEC Table C groundwater cleanup levels among FS1-33F, FS1-33H, TS1-33O2, TS1-33Q, and TS1-33UR. Results for all other analytes were either non-detect or were detected below ADEC Table C groundwater cleanup levels. Contaminant concentrations were observed to be generally consistent with historical observations. Additionally, 10-foot screens were confirmed for wells FS1-33S and TS1-33Q and a 5-foot screens was confirmed for well FS1-33F during inspection and maintenance activities (BESC 2019a).

4.4.3 TS 1-33 2021 Monitoring Well Inspections and Maintenance

All TS 1-33 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 4-9 includes a well maintenance summary for TS 1-33.

Table 4-7: SRF TS 1-33 Well Maintenance Summary

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
TS1-33JJ	Good				14.00	2”	10’ screen.
TS1-33KK	Good				8.71	2”	Septic odor.
TS1-33N	To be decommissioned.						
TS1-33O2	Poor				10.90	2”	Monument destroyed, no lid. Difficult access under pipeline. 10’ screen.
TS1-33P	Good	X			9.29	2”	
TS1-33Q	Good	X			10.86	2”	10’ screen.
TS1-33UR	Good			X	9.11	2”	10’ screen. Sock placed in 2019; replace sock if LNAPL present.

Table 4-9: SRF TS 1-33 Well Maintenance Summary (continued)

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
FS1-33F	Good				28.10	2”	5’ screen.
FS1-33H	Fair	X		X	25.23	2”	Sock placed in 2019; replace sock if LNAPL present. 5’ screen.
FS1-33O	Good				29.11	2”	Potentially false water signal ~17’ btoc.
FS1-33S	Poor				25.86	2”	Monument damaged; PVC condition is good. 10’ screen.
FS1-33W	Good				23.72	2”	10’ screen.
FS1-33T	Good				20.93	2”	
MW1-33A	To be decommissioned; destroyed.						

Notes:
For definitions, see Acronyms and Abbreviations section.
1 All wells Schedule 40 PVC unless otherwise indicated.
2 Shaded rows indicate wells previously destroyed or to be decommissioned. Wells to be decommissioned and/or installed are addressed under a separate work plan.

4.4.4 TS 1-33 2021 Groundwater Monitoring Activities

TS 1-33 groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. The planned field activities for 2021 groundwater monitoring at TS 1-33 are summarized below:

- Gauge groundwater levels in all monitoring wells within a 2-hour period in order to determine groundwater elevation and flow direction.
- TS1-33UR: Sample well for petroleum-related VOCs (including BTEX) and PAHs.
- TS1-33O2, TS1-33Q, FS1-33F, FS1-33H, and FS1-33S: Sample for 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, benzo(a)anthracene, cumene, naphthalene, tert-butylbenzene, xylenes, 1-methylnaphthalene, and 2-methylnaphthalene.
- FS1-33W and TS1-33JJ: Sample for petroleum-related VOCs (including BTEX) and PAHs at a frequency of every four years. These wells are scheduled to be sampled in 2023.
- TS1-33N: Decommission (decommission/installation activities completed under a separate work plan).
- MW1-33A: Decommission (decommission/installation activities completed under a separate work plan). Well MW1-33A is not in the sampling program and has been damaged by the flare.
- FS1-33S: Repair damaged monument casing during decommission/installation activities completed under a separate work plan.
- Resurvey all TS 1-33 wells during decommission/installation activities completed under a separate work plan to determine top of casing elevations.

Table 4-10 identifies the TS 1-33 wells and sample analyses. Monitoring well locations are presented on Figure 6.

Table 4-8: SRF TS 1-33 Summary of Monitoring Wells and 2021 Analyses

WELL ID	GAUGE	ANALYSES / METHOD			
		SW8260C		SW8270SIM	
		VOCs[1]	Select VOCs[2]	PAH[1]	Select PAH[3]
TS1-33JJ	X				
TS1-33KK	X				
TS1-33O2	X		X		X
TS1-33P	X				
TS1-33Q	X		X		X
TS1-33UR	X	X		X	
FS1-33F	X		X		X
FS1-33H	X		X		X
FS1-33O	X				
FS1-33S	X		X		X
FS1-33T	X				
FS1-33W	X				

Notes:
For definitions, see Acronyms and Abbreviations section.
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, cumene, tert-butylbenzene, and xylenes.
3 PAH analytes reduced in 2019 to include only benzo(a)anthracene, naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene.

4.5 SRF TS 2-15

TS 2-15 is located approximately 4 miles north of TS 1-4 (Figure 2). 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 TS 2-15.

4.5.1 TS 2-15 Geology and Hydrogeology

Groundwater at TS 2-15 has historically been observed to flow to the west-northwest during summer/fall sampling events, and groundwater elevation is approximately 310 feet relative to the NAVD88 (SLR 2015; BESC 2016e, 2019b). In 2019, groundwater elevations ranged between 299.84 feet and 313.36 feet (NAVD88) at TS 2-15, and estimated direction of groundwater was northwest, which is generally consistent with historical observations (BESC 2019a).

4.5.2 TS 2-15 Previous Investigation and Monitoring Activities

Monitoring wells TS2-15O and FS2-15B were installed at TS 2-15 by 1990. Three additional wells TS2-15P, TS2-15Q, and TS2-15R were installed in 2002. The groundwater monitoring wells at TS 2-15 were sampled for BTEX on an annual basis from 2000 to 2010. Between 2011 and 2013, groundwater monitoring did not occur, but monitoring resumed in 2014. The site was moved to a periodic sampling basis in 2015 with the site wells split between two sampling frequencies, biennial and once every 4 years. Concentrations of benzene, ethylbenzene, and xylenes have exceeded the ADEC Table C groundwater cleanup levels in samples from monitoring well TS2-15O since 2000. Concentrations of toluene in TS2-15O exceeded the ADEC Table C groundwater cleanup level in 2000 but have been below current cleanup levels since 2001. Since 2000, BTEX has not been detected or has been detected at low concentrations in samples collected from monitoring wells TS2-15P, TS2-15Q, TS2-15R, and FS2-15B. LNAPL has not been observed in any of the monitoring wells at TS 2-15 (SLR 2015; BESC 2016e).

In 2017, monitoring well TS2-15O was sampled for petroleum-related VOCs (including BTEX) and PAHs. Ethylbenzene and naphthalene concentrations exceeded ADEC Table C groundwater cleanup levels in well TS2-15O. Contaminant concentration trends were observed to be generally consistent with historical observations and, although consistent, concentrations of benzene and xylenes were below cleanup levels (BESC 2019b).

In 2019, monitoring wells TS2-15O, TS2-15P, TS2-15R, and FS2-15B were sampled for petroleum-related VOCs (including BTEX) and PAH. Concentrations of 1,2,4-trimethylbenzene, benzene, ethylbenzene, naphthalene, and xylenes in well TS2-15O exceeded ADEC Table C groundwater cleanup levels. Results for all other analytes were either non-detect or were detected below ADEC Table C groundwater cleanup levels. Contaminant concentrations are observed to be generally consistent with historical observations. Additionally, 10-foot screen lengths were confirmed for wells FS2-15B and TS2-15O (BESC 2019a).

4.5.3 TS 2-15 2021 Monitoring Well Inspections and Maintenance

All TS 2-15 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 4-11 includes a well maintenance summary for TS 2-15.

Table 4-9: SRF TS 2-15 Well Maintenance Summary

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
TS2-15O	Fair				11.55	2”	Faint HC odor in 2019. 10’ screen.
TS2-15P	Good				12.51	2”	10’ screen.
TS2-15Q	Good				16.67	2”	
TS2-15R	Fair				13.80	2”	Broken monument lid. 10’ screen.
FS2-15B	Good				15.56	2”	10’ screen.

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

4.5.4 TS 2-15 2021 Groundwater Monitoring Activities

TS 2-15 groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. The planned field activities for 2021 groundwater monitoring at TS 2-15 are summarized below:

- The vegetation at and surrounding TS 2-15 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.
- TS2-15O: Sample for 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, naphthalene, xylenes, and 1-methylnaphthalene.

- FS2-15B, TS2-15P, TS2-15R: Sample for petroleum-related VOCs (including BTEX) and PAHs at a frequency of every four years. These wells are scheduled to be sampled in 2023.
- TS2-15R: Repair broken monument lid during decommission/installation activities completed under a separate work plan.
- Resurvey all TS 2-15 wells during decommission/installation activities completed under a separate work plan to determine top of casing elevations.

Table 4-12 identifies the TS 2-15 wells and sample analyses. Monitoring well locations are presented on Figure 7.

Table 4-10: SRF TS 2-15 Summary of Monitoring Wells and 2021 Analyses

WELL ID	GAUGE	ANALYSES / METHOD			
		SW8260C		SW8270SIM	
		VOCs[1]	Select VOCs[2]	PAH[1]	Select PAH[3]
TS2-15O	X		X		X
TS2-15P	X				
TS2-15Q	X				
TS2-15R	X				
FS2-15B	X				

Notes:
For definitions, see Acronyms and Abbreviations section.
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 and 1-methylnaphthalene.

4.6 SRF TS 3-4

TS 3-4 is located less than a mile southwest of TS 1-4 (Figure 2). 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 TS 3-4.

4.6.1 TS 3-4 Geology and Hydrogeology

Groundwater at TS 3-4 has historically been observed to flow generally to the southeast during summer/fall sampling events, and the groundwater elevation is approximately 146 feet relative to the NAVD88 (Oil Risk 2011; SLR 2015; BESC 2016f, 2019b). In 2019, groundwater elevations across TS 3-4 ranged from 138.51 feet to 150.27 feet (NAVD88), and estimated direction of groundwater was east, which is generally consistent with historical observations (BESC 2019a).

4.6.2 TS 3-4 Previous Investigation and Monitoring Activities

Seven monitoring wells were installed by 1990, and five additional monitoring wells were installed in 2002. The groundwater monitoring wells at TS 3-4 were sampled for BTEX on an annual basis from 2000 to 2010. Between 2011 and 2013, groundwater monitoring did not occur, but monitoring resumed in 2014. The site was moved to a periodic sampling basis in 2015 with the site wells split between two sampling frequencies, biennial and every 4 years.

BTEX analytes have been detected at concentrations exceeding ADEC Table C groundwater cleanup levels in wells TS3-4D, TS3-4P, FS3-4D, and FS3-4F since groundwater monitoring began in 2000, and in TS3-4CC since it was installed in 2002. LNAPL was observed in TS3-4D and FS3-4D during previous sampling events as well as the most current sampling event. During previous sampling events, results for all BTEX analytes in monitoring wells TS3-4Z, TS3-4MM, TS3-4NN, TS3-4OO, TS3-4PP, FS3-4A, and FS3-4B were non-detect or below the ADEC Table C groundwater cleanup levels (SLR 2015; BESC 2016f). No surface water was observed at or adjacent to the site, and it was determined that contaminated groundwater was adequately bound downgradient by uncontaminated monitoring wells TS3-4MM, FS3-4A, and FS3-4B (BESC 2016f).

In 2017, concentrations of 1,2,4-trimethylbenzene, benzene, ethylbenzene, naphthalene, and 1-methylnaphthalene exceeded the ADEC Table C groundwater cleanup level among monitoring wells TS3-4CC, TS3-4P, and FS3-4F. Product was detected in wells FS3-4D and TS3-4D, and they were not sampled. At approximately 18 feet btoc, an obstruction in TS3-4CC prevented deployment of a HydraSleeve, and VOC samples were collected using a peristaltic pump (BESC 2019b).

In 2019, monitoring wells TS3-4CC, TS3-4MM, TS3-4OO, TS3-4P, FS3-4A, FS3-4B, and FS3-4F were sampled for petroleum-related VOCs (including BTEX) and PAH. LNAPL was detected in wells FS3-4D and TS3-4D, and they were not sampled. Absorbent socks were placed in both wells. Trace amounts of product were detected at TS3-4D, and approximately 2.5 gallons of product was recovered from FS3-4D. Concentrations of benzene, ethylbenzene, and naphthalene exceeded ADEC Table C groundwater cleanup levels in well TS3-4P, as did concentrations of naphthalene in well TS3-4CC. Results for all other analytes were either non-detect or were detected below ADEC Table C groundwater cleanup levels. Contaminant concentrations were observed to be generally consistent with historical observations; however, all results were below ADEC Table C groundwater cleanup levels in well FS3-4F, compared to several exceedances that were observed during monitoring in 2017. Additionally, 10-foot screens were confirmed for wells FS3-4A, FS3-4B, FS3-4F, and TS3-4P during inspection and maintenance activities (BESC 2019a).

4.6.3 TS 3-4 2021 Monitoring Well Inspections and Maintenance

All TS 3-4 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 4-13 includes a well maintenance summary for TS 3-4.

Table 4-11: SRF TS 3-4 Well Maintenance Summary

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
TS3-4D	Good			X	15.34	2”	Product detected on water level meter tape and probe. Sock placed in 2019; replace sock if LNAPL present.
TS3-4P	Good				10.47	2”	Faint HC odor in 2019. 10’ screen.
TS3-4Z	Good				12.41	2”	
TS3-4CC	Fair				13.13	2”	10’ screen.
TS3-4MM	Heaved	X			8.26	2”	10’ screen.
TS3-4NN	Heaved	X			8.87	2”	
TS3-4OO	Heaved	X			7.31	2”	Loose monument casing observed in 2019. 10’ screen.
TS3-4PP	Fair				7.97	2”	Loose monument casing observed in 2019.

Table 4-13: SRF TS 3-4 Well Maintenance Summary (continued)

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
FS3-4A	Heaved	X			14.20	2”	Loose monument casing and tilted PVC observed in 2019. 10’ screen.
FS3-4B	Heaved	X			9.04	2”	10’ screen.
FS3-4D	Heaved	X	X	X	-	1”	Smaller- diameter PVC nested inside 2” Sch 40. Removed ~2.5 gallons of product in 2019.
FS3-4F	Fair				14.03	2”	Monument slightly titled. 10’ screen.

Notes:
For definitions, see Acronyms and Abbreviations section.
- Unknown or not determined
[1] All wells Schedule 40 PVC unless otherwise indicated.

4.6.4 TS 3-4 2021 Groundwater Monitoring Activities

SRF TS 3-4 groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. The planned field activities for 2021 groundwater monitoring at TS 3-4 are summarized below:

- The vegetation at and surrounding TS 3-4 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.
- TS3-4D and FS3-4D: Remove LNAPL and replace LNAPL-absorbent socks. If LNAPL is not present, sample wells for petroleum-related VOCs (including BTEX) and PAHs. As FS3-4D is a 1-inch well, it is recommended to use a smaller diameter LNAPL-absorbent sock, a bailer, or a pump to remove LNAPL.
- TS3-4P, TS3-4CC, FS3-4A, and FS3-4F: Sample for 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, naphthalene, xylenes, and 1-methylnaphthalene.
- TS3-4MM, TS3-4OO, and FS3-4B: Sample for petroleum-related VOCs (including BTEX) and PAHs at a frequency of every four years. These wells are scheduled to be sampled in 2023.
- Resurvey all TS 3-4 wells during decommission/installation activities completed under a separate work plan to determine top of casing elevations.

Table 4-14 identifies the SRF TS 3-4 wells and sample analyses. Monitoring well locations are presented on Figure 8.

Table 4-12: SRF TS 3-4 Summary of Monitoring Wells and 2021 Analyses

WELL ID	GAUGE	ANALYSES / METHOD			
		SW8260C		SW8270SIM	
		VOCs[1]	Select VOCs[2]	PAH[1]	Select PAH[3]
TS3-4D	X	X		X	
TS3-4P	X		X		X
TS3-4Z	X				
TS3-4CC	X		X		X

Table 4-14: SRF TS 3-4 Summary of Monitoring Wells and Analyses (continued)

WELL ID	GAUGE	ANALYSES / METHOD			
		SW8260C		SW8270SIM	
		VOCs[1]	Select VOCs[2]	PAH[1]	Select PAH[3]
TS3-4MM	X				
TS3-4NN	X				
TS3-4OO	X				
TS3-4PP	X				
FS3-4A	X		X		X
FS3-4B	X				
FS3-4D	X	X		X	
FS3-4F	X		X		X

Notes:
For definitions, see Acronyms and Abbreviations section.
Yellow highlight indicates that LNAPL was observed in this 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, ethylbenzene, and xylenes.
3 PAH analytes reduced in 2019 to include only naphthalene and 1-methylnaphthalene.

4.7 SRF TS 3-9

TS 3-9 is located approximately 1.75 miles southwest of TS 1-4 (Figure 2). The following sections include site-specific information about site geology and hydrogeology, previous investigations and groundwater monitoring, and planned 2021 groundwater monitoring activities at TS 3-9.

4.7.1 TS 3-9 Geology and Hydrogeology

Groundwater at TS 3-9 has historically been observed to flow generally to the east during summer/fall sampling events, and the groundwater elevation is approximately 150 feet relative to the NAVD88. Observed groundwater flow direction slightly deviated from historical observations in 2014 when groundwater flow was toward the southeast, and in 2015 and 2017, when groundwater flowed generally northeast (Oil Risk 2011; SLR 2015; BESC 2016g, 2019b).

In 2019, groundwater elevations ranged between 146.65 feet and 149.83 feet at TS 3-9, and estimated direction of groundwater flow in 2019 was generally southeast, which varies slightly from historical northeast observations in 2015 and 2017 but is consistent with 2014 historical observations (BESC 2019a).

4.7.2 TS 3-9 Previous Investigation and Monitoring Activities

Ten monitoring wells were installed by 1990, and four additional monitoring wells (TS3-9AA, TS3-9BB, TS3-9CC, and TS3-9DD) were installed in 2002. The groundwater monitoring wells at TS 3-9 were sampled for BTEX on an annual basis from 2000 to 2010. Between 2011 and 2013, groundwater monitoring did not occur, but monitoring resumed in 2014. The site was moved to a periodic sampling basis in 2015 with the site wells split between two sampling frequencies, biennial and every 4 years.

Benzene, ethylbenzene, and xylenes have been detected in groundwater samples collected at TS 3-9 at concentrations exceeding the ADEC Table C groundwater cleanup level since 2000. Analytes with concentrations consistently exceeding the ADEC Table C groundwater cleanup levels since 2000 include benzene in samples collected from four monitoring wells (TS3-9C/9CR, TS3-9F, TS3-9V, and FS3-9E), ethylbenzene in samples collected from four monitoring wells (TS3-9C, TS3-9F, TS3-9T, and FS3-9E), and xylenes in samples collected from two monitoring wells (TS3-9C/CR and TS3-9F). Benzene, ethylbenzene, and xylenes consistently exceeded ADEC Table C groundwater cleanup levels in monitoring well TS3-9C from 2000 to 2010; however, it was no longer sampled after 2010 due to LNAPL presence in 2014 and an obstruction in the well in 2015. It was decommissioned in 2017 and replaced with monitoring well TS3-9CR, which again exceeded ADEC Table C groundwater cleanup levels for only benzene and xylenes.

Benzene concentrations have exceeded ADEC Table C groundwater cleanup level occasionally in samples collected from seven monitoring wells at TS 3-9: eight times in samples collected from TS3-9A (most recently in 2007), nine times in samples collected from in TS3-9S (most recently in 2009), 12 times in samples collected from TS3-9T (most recently in 2017), five times in samples collected from in TS3-9U (most recently in 2014), once in TS3-9AA (2005), seven times in samples collected from TS3-9BB (most recently in 2019), and once in FS3-9B (2002) (BESC 2016g, 2019a, 2019b). Ethylbenzene concentrations have occasionally exceeded the ADEC Table C groundwater cleanup level in samples collected from seven monitoring wells at TS 3-9: once in TS3-9A (2002), four times in samples collected from TS3-9S (most recently in 2002), twice in samples collected from TS3-9U (2000 and 2003), seven times in samples collected from TS3-9V (most recently in 2015), four times in samples collected from TS3-9AA (most recently in 2006), nine times in samples collected from TS3-9BB (most recently in 2019), and once in FS3-9B (2002). Xylene concentrations have exceeded the ADEC Table C groundwater cleanup level occasionally in samples collected from three monitoring wells at TS 3-9: once in TS3-9A (2010), once in TS3-9U (2003), and nine times in samples collected from FS3-9E (most recently in 2010) (BESC 2016g, 2019b). Since 2000, BTEX concentrations in TS3-9CC, TS3-9DD, and FS3-9G have not been detected or have been detected at low concentrations.

LNAPL has been observed in TS3-9A (most recently in 2019), TS3-9C (most recently in 2015 and decommissioned in 2017), TS3-9F (most recently in 2017), TS3-9T (most recently in 2002), TS3-9U (most recently in 2005), and FS3-9E (most recently in 2019) (BESC 2016g, 2019a, 2019b).

In 2017, monitoring wells TS3-9BB, TS3-9CR, TS3-9T, and TS3-9V were sampled for petroleum-related VOCs (including BTEX) and PAHs. The 2017 groundwater monitoring results indicated exceedances of 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, naphthalene, and xylenes above ADEC Table C groundwater cleanup levels. Results for all other analytes were either non-detect or below the ADEC Table C groundwater cleanup levels. Some additional PAH analytes had non-detect results with reporting limits exceeding ADEC Table C groundwater cleanup levels. Monitoring wells TS3-9A, TS3-9F, TS3-9U and FS3-9E contained LNAPL and were not sampled. The previous monitoring well TS3-9C contained LNAPL, but the replacement well TS3-9CR did not contain LNAPL and analyte concentrations were significantly less than that of TS3-9C. Contaminant concentrations were observed to be consistent with historical observations, except for LNAPL detected in TS3-9F and FS3-9E (BESC 2019b).

In 2019, monitoring wells TS3-9AA, TS3-9BB, TS3-9DD, TS3-9CR, TS3-9F, TS3-9T, TS3-9U, TS3-9V, FS3-9B, and FS3-9G were sampled for petroleum-related VOCs (including BTEX) and PAH. LNAPL was detected in monitoring wells TS3-9A and FS3-9E, and these wells were not sampled. Concentrations of 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, ethylbenzene, naphthalene, xylenes, and 1-methylnaphthalene exceeded ADEC Table C groundwater cleanup levels among wells TS3-9BB, TS3-9CR, TS3-9F, TS3-9T, and TS3-9V. Results for all other analytes were either non-detect or were detected below ADEC Table C groundwater cleanup levels. Contaminant concentrations were generally consistent with historical observations. Additionally, 10-foot screens were confirmed for wells TS3-9U and TS3-9V, 5-foot screens were confirmed for wells TS3-9F and FS3-9G, and a 15-foot screen was confirmed for well TS3-9T (BESC 2019a).

4.7.3 TS 3-9 2021 Monitoring Well Inspections and Maintenance

All TS 3-9 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 4-15 includes a well maintenance summary for TS 3-9.

Table 4-13: SRF TS 3-9 Well Maintenance Summary

Well ID	2019 Observations					Well Diameter[1]	Notes
	Condition	Heaving Noted	LNAPL	Absorbent Sock	Depth to Water (feet btoc)		
TS3-9A	Good		X	X	17.06	2”	Replace sock if LNAPL present.
TS3-9CR	Good				19.43	2”	Slight HC odor in 2019. 10’ screen.
TS3-9F	Fair			X	19.56	2”	Trace product on oil-water interface probe in 2019. PVC casing coated with product/residue. Sock flipped; replace sock if LNAPL present. 5’ screen.
TS3-9S	Good				15.67	2”	
TS3-9T	Good				17.33	2”	Bailer located in monument. Slight HC odor in 2019. 15’ screen.
TS3-9U	Good			X	16.83	2”	Sock flipped in 2019; replace sock if LNAPL present. 10’ screen.
TS3-9V	Good				9.21	2”	10’ screen.
TS3-9AA	Good				16.97	2”	10’ screen.
TS3-9BB	Good				18.22	2”	10’ screen.
TS3-9CC	Good				9.86	2”	Broken monument lid and collar. Mislabeled as “TS3-9T” and corrected to “TS3-9CC” in 2019.
TS3-9DD	Good				9.05	2”	10’ screen.
FS3-9B	Good				14.73	2”	10’ screen.
FS3-9E	Good		X	X	12.20	2”	Replace sock if LNAPL present.
FS3-9G	Good	X			11.68	2”	PVC casing tilted against monument. 5’screen.

Notes:
For definitions, see Acronyms and Abbreviations section.
- Unknown or not determined
[1] All wells Schedule 40 PVC unless otherwise indicated.

4.7.4 TS 3-9 2021 Groundwater Monitoring Activities

TS 3-9 groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. The planned field activities for 2021 groundwater monitoring at TS 3-9 are summarized below:

- The vegetation at and surrounding TS 3-9 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.
- TS3-9A and FS3-9E: Monitor and remove LNAPL and replace absorbent socks. If LNAPL is not present, sample wells for petroleum-related VOCs (including BTEX) and PAHs.
- TS3-9BB, TS3-9CR, TS3-9F, TS3-9T, TS3-9U, and TS3-9V: Sample for petroleum-related VOCs (including BTEX), and PAHs.
- TS3-9AA, TS3-9DD, FS3-9B, and FS3-9G: Sample for petroleum-related VOCs (including BTEX) and PAHs at a frequency of every four years. These wells are scheduled to be sampled in 2023.
- TS3-9CC: Repair monument lid and collar during decommission/installation activities completed under a separate work plan.
- Resurvey all TS 3-9 wells during decommission/installation activities completed under a separate work plan to determine top of casing elevations.

Table 4-16 identifies the TS 3-9 wells and sample analyses. Monitoring well locations are presented on Figure 9.

Table 4-14: SRF TS 3-9 Summary of Monitoring Wells and 2021 Analyses

WELL ID	GAUGE	ANALYSES / METHOD	
		SW8260C	SW8270SIM
		VOCs[1]	PAH[1]
TS3-9A	X	X	X
TS3-9CR	X	X	X
TS3-9F	X	X	X
TS3-9S	X		
TS3-9T	X	X	X
TS3-9U	X	X	X
TS3-9V	X	X	X
TS3-9AA	X		
TS3-9BB	X	X	X
TS3-9CC	X		
TS3-9DD	X		
FS3-9B	X		
FS3-9E	X	X	X
FS3-9G	X		

Notes:
For definitions, see Acronyms and Abbreviations section.
Yellow highlight indicates that LNAPL was observed in this well in 2019. Samples will be collected if no LNAPL is observed during 2021 activities.
1 Full list analysis. Petroleum-related VOCs include BTEX.

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5.0 REFERENCES

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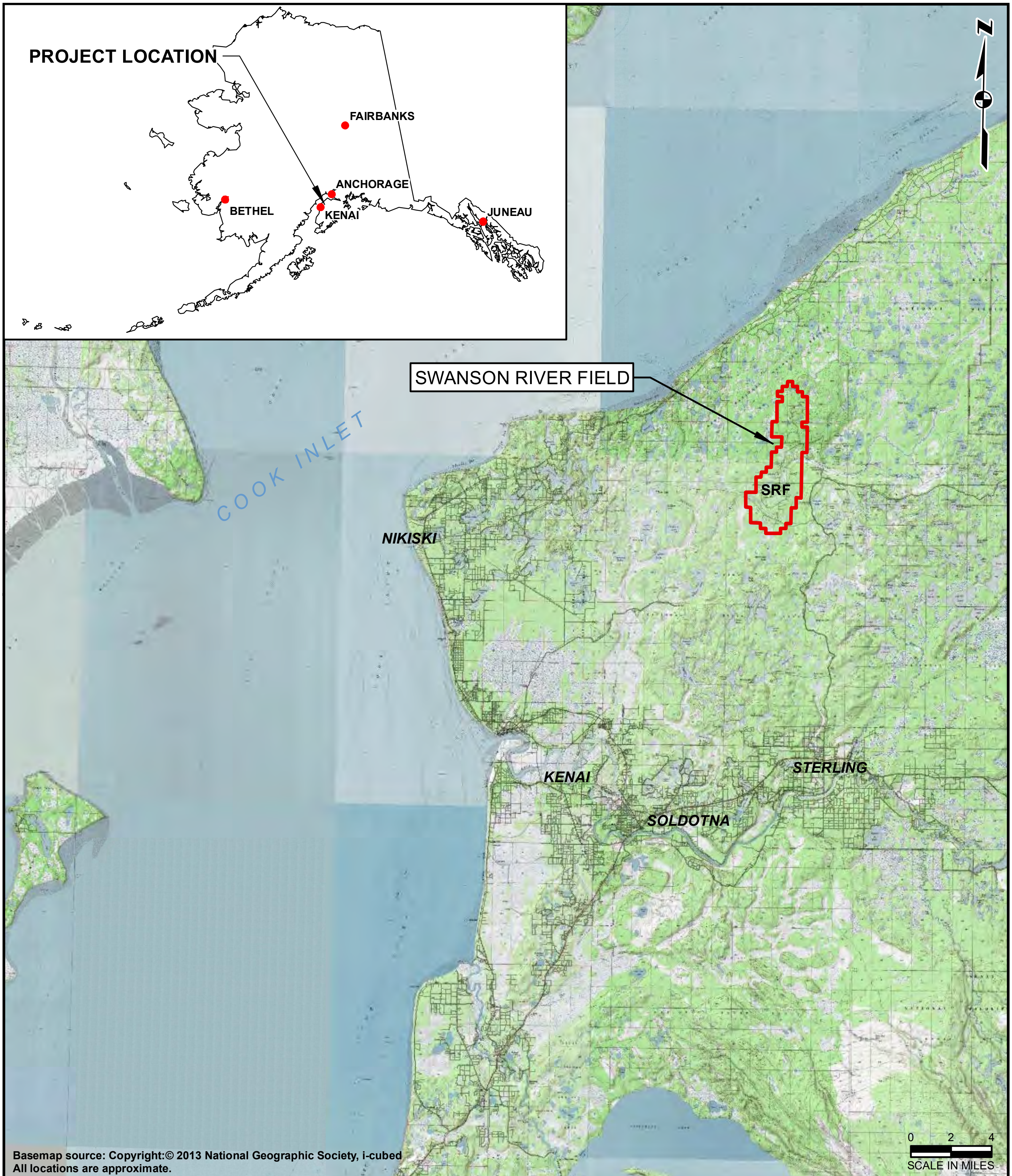
APPENDIX A:
FIGURES



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2021 GROUNDWATER MONITORING PROGRAM WORK PLAN
SWANSON RIVER FIELD

KENAI PENINSULA, ALASKA

STATE AND SITE VICINITY

DATE: 5/17/2021

PROJECT No.: 760201

DRAWN: JC

FIGURE: 1

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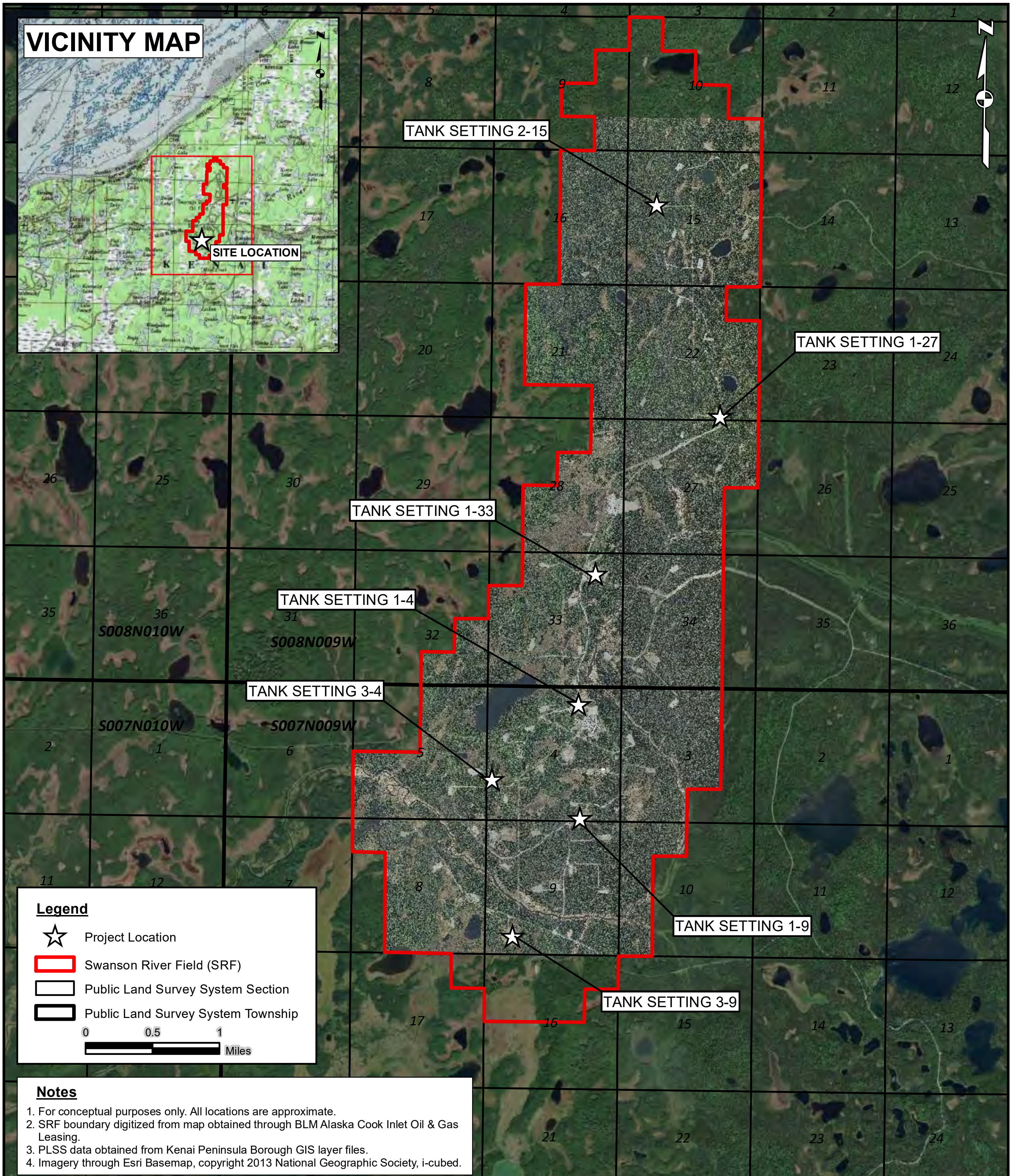

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2021 GROUNDWATER MONITORING PROGRAM WORK PLAN
KENAI PENINSULA, ALASKA

SWANSON RIVER FIELD
SITE MAP

DATE:	5/17/2021
PROJECT No.:	760201
DRAWN:	JC
FIGURE:	2

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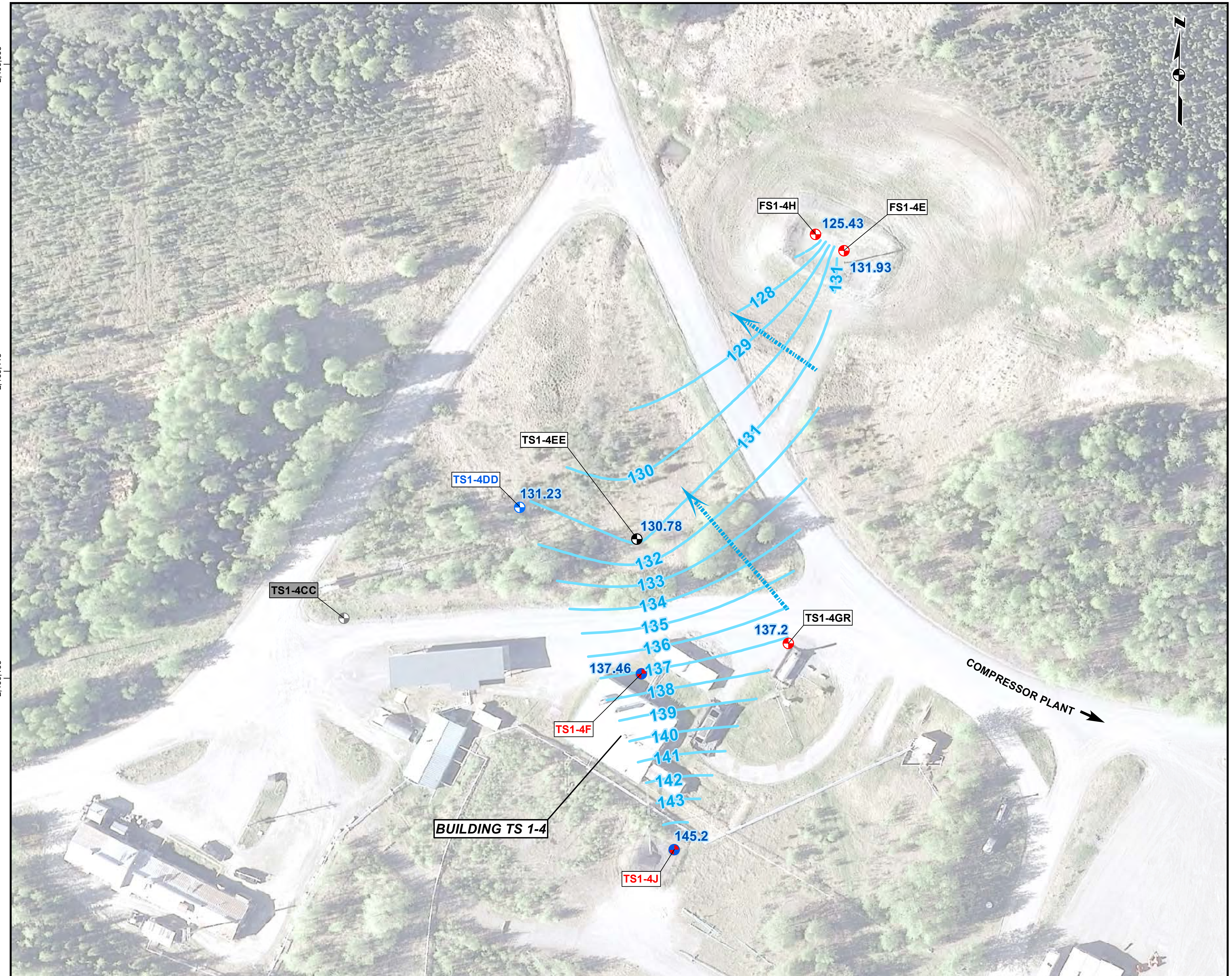

2021 GROUNDWATER MONITORING PROGRAM REPORT - SWANSON RIVER FIELD

KENAI PENINSULA, ALASKA

SWANSON RIVER FIELD TANK SETTING 1-4 MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

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

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. 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 FS1-4E, FS1-4H, TS1-4DD, TS1-4EE, TS1-4GR, and TS1-4J.
6. Monitoring well TS1-4CC is excluded from groundwater monitoring activities due to damage.

80 40 0 80 FEET

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

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PROJECT No.: 760201	DATE: 5/17/2021	FIGURE: 3
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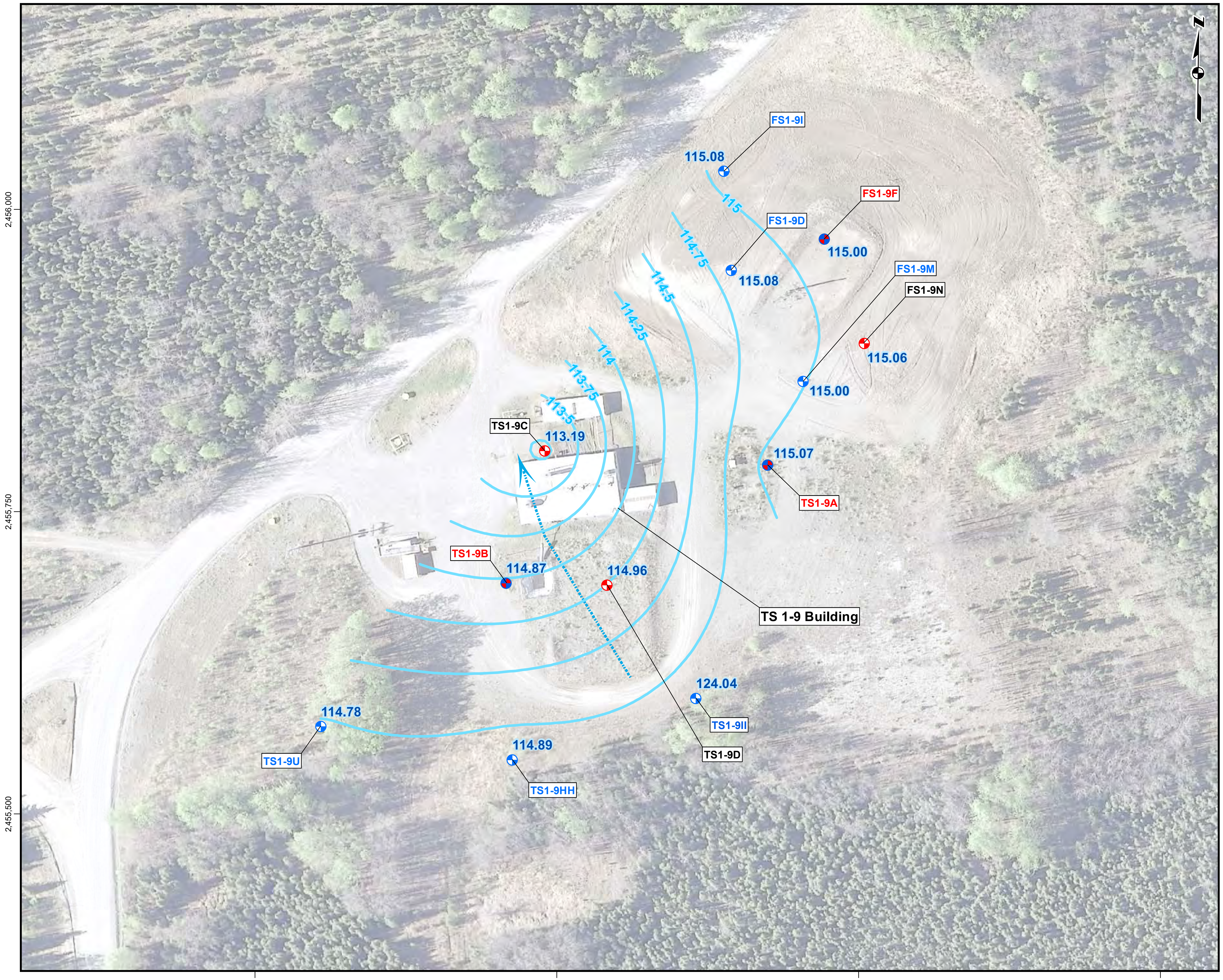

2021 GROUNDWATER MONITORING PROGRAM REPORT - SWANSON RIVER FIELD

KENAI PENINSULA, ALASKA

SWANSON RIVER FIELD TANK SETTING 1-9 MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

Approximate Groundwater Flow Direction

XX.XX Groundwater Elevation (feet)

100.00 Groundwater Contour with Elevation

Monitoring Well Location

- Gauge - LNAPL Previously Present; Sample if no LNAPL Detected
- Gauge Only
- 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 FS1-9I, FS1-9N, TS1-9A, TS1-9C, TS1-9HH, and TS1-9U.
6. Monitoring well TS1-9II was designated as a water table monitoring well; however, in 2019, the calculated groundwater elevation calculated was anomalous and not considered representative. This well was replaced withTS1-9HH in the 2019 model.

80 40 0 80 FEET

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

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2021 GROUNDWATER MONITORING PROGRAM REPORT - SWANSON RIVER FIELD

KENAI PENINSULA, ALASKA

SWANSON RIVER FIELD TANK SETTING 1-27 MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

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

Monitoring Well Location

- Gauge Only
- 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 FS1-27C, TS1-27G, TS1-27K, TS1-27L, TS1-27M, and TS1-27N.

80 40 0 80 FEET

ALASKA STATE PLANE ZONE 4, US SURVEY FEET

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

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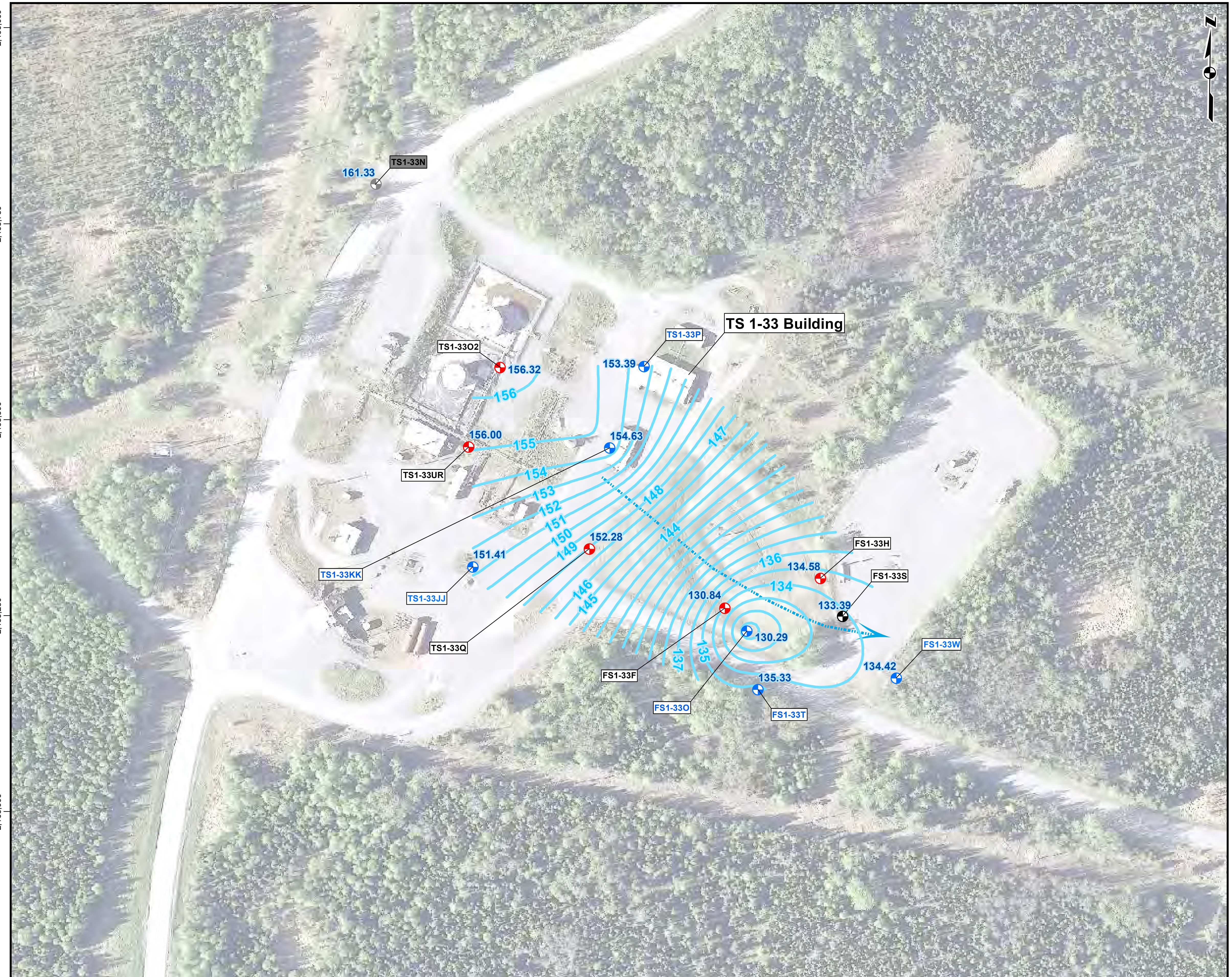

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2021 GROUNDWATER MONITORING PROGRAM REPORT - SWANSON RIVER FIELD

KENAI PENINSULA, ALASKA

SWANSON RIVER FIELD TANK SETTING 1-33 MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

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

Monitoring Well Location

- Gauge Only
- Gauge and Sample
- Gauge and Sample; Previous Exceedance
- To be Decommissioned

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 FS1-33H, FS1-33O, FS1-33T, FS1-33W, TS1-33JJ, TS1-33KK, TS1-33P, and TS1-33UR.

125 62.5 0 125 FEET

ALASKA STATE PLANE ZONE 4, US SURVEY FEET

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

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2021 GROUNDWATER MONITORING PROGRAM REPORT - SWANSON RIVER FIELD

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SWANSON RIVER FIELD TANK SETTING 2-15 MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

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

Monitoring Well Location

- Gauge Only
- 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 FS2-15B, TS2-15O, TS2-15P, TS2-15Q, and TS2-15R.

60 30 0 60 FEET

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

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2021 GROUNDWATER MONITORING PROGRAM REPORT - SWANSON RIVER FIELD

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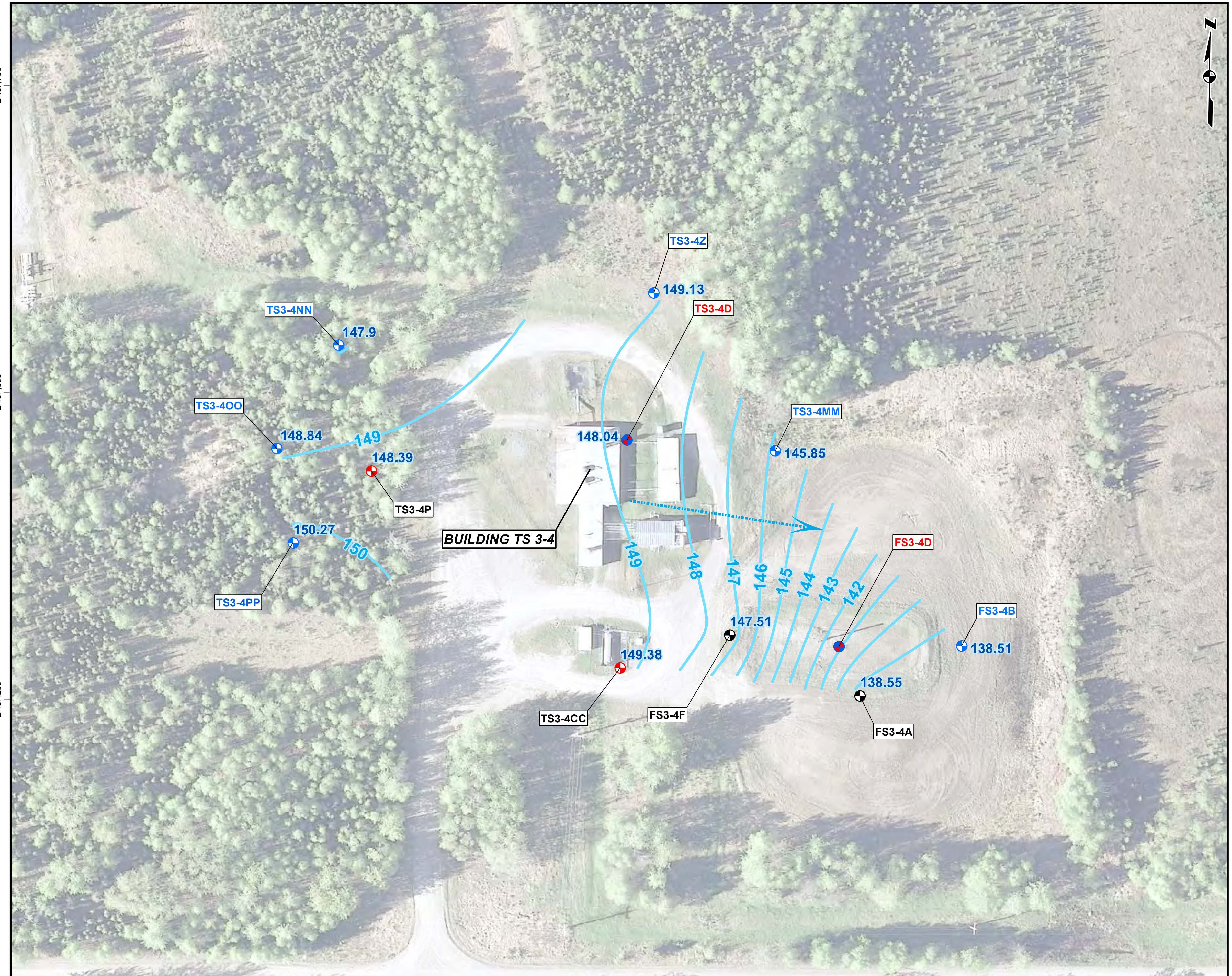
SWANSON RIVER FIELD TANK SETTING 3-4 MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION



2,457,750
2,457,500
2,457,250
1,482,250
1,482,500
1,482,750
1,483,000

Legend

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

Monitoring Well Location

- Gauge - LNAPL Previously Present; Sample if no LNAPL Detected
- 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 FS3-4A, FS3-4B, FS3-4F, TS3-4CC, TS3-4MM, TS3-4NN, TS3-4OO, TS3-4PP, and TS3-4Z.

80 40 0 80 FEET

ALASKA STATE PLANE ZONE 4, US SURVEY FEET

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

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PROJECT No.: 760201	DATE: 5/17/2021	FIGURE: 8
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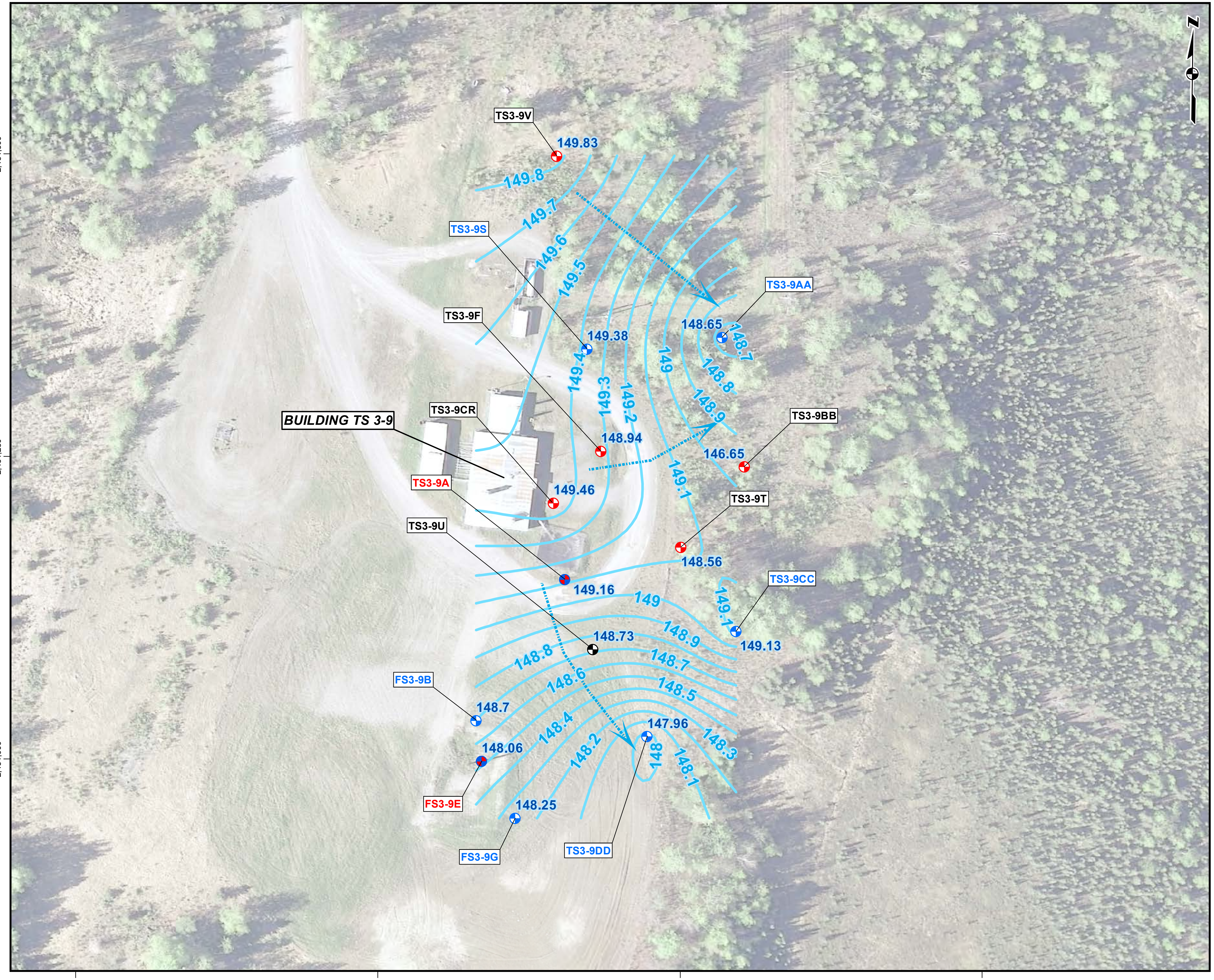

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2021 GROUNDWATER MONITORING PROGRAM REPORT - SWANSON RIVER FIELD

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SWANSON RIVER FIELD TANK SETTING 3-9 MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

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

Monitoring Well Location

- Gauge - LNAPL Previously Present; Sample if no LNAPL Detected
- 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 FS3-9B, FS3-9G, TS3-9AA, TS3-9CC, TS3-9CR, TS3-9DD, TS3-9S, TS3-9V.
6. The groundwater elevation in well TS3-9BB was a significant outlier compared to the nearest wells omitted from the 2019 groundwater mode.
7. TS3-9A had a significant presence (> 1') of LNAPL in 2019. Groundwater elevation in this well was omitted from the 2019 groundwater model.

80 40 0 80 FEET

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

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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: Signature/Printed Name Date/Time

Relinquish By: Signature/Printed Name Date/Time

Received By: Signature/Printed Name Date/Time

Received By: 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

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:

Pump Type: Flow Rate (gpm):

Pump Time:

Bailer: TEFLON SS OTHER:

Required Pulls: Bailer Vol. (gal): 0.25 / 0.33

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-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

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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 24 hours after installation.

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
		______ Casing Stickup
9		______ Depth of Well
		______ Depth of Boring
10		______ Depth to Groundwater from ______ on (date) ______
11		Development Method ______
12		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.

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.

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.